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AIRPORT QUOTAS AND PEAK HOUR PRICING: THEORY AND PRACTICE.(U)
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U.S. DEPARTMENT OF TRANSPORTATION
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16. Abstract

This report examines the leading theoretical studies not only of airport peak-hour pricing but also of the congestion costs associated with airport delays and presents a consistent formulation of both. The report also considers purely administrative measures, such as quotas, and hybrid systems which combine administrative and economic control techniques. These are all compared to the real-world situation and problems of implementation discussed.

The actual experiences of the Port Authority of New York and New Jersey at the three major New York area airports and the British Airports Authority at Heathrow are then presented. Both organizations administer hybrid quota/peak-hour pricing systems in conjunction with their respective air traffic control authorities. Their experience is compared with the theoretical analyses.

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ABSTRACT

Capital investment has been the traditional means of expanding airport capacity. However, as the cost of capital expansion increases, non-capital-intensive techniques such as operational quota systems or peak-hour surcharges have been proposed as alternatives. Although these measures do not physically expand capacity, they postpone the need for expansion by promoting more intensive and more economically efficient use of existing capacity.

This report examines the leading theoretical studies not only of airport peak-hour pricing but also of the congestion costs associated with airport delays and presents a consistent formulation of both. The report also considers purely administrative measures, such as quotas, and hybrid systems which combine administrative and economic control techniques. These are all compared to the real-world situation and problems of implementation discussed.

The actual experiences of the Port Authority of New York and New Jersey at the three major New York area airports and the British Airports Authority at Heathrow are then presented. Both organizations administer hybrid quota/peak-hour pricing systems in conjunction with their respective air traffic control authorities. Their experience is compared with the theoretical analyses.

The conclusions are that non-capital-intensive techniques are effective in shifting the demand for airport services and, as a result, in increasing utilization and in decreasing delays. The potential savings from postponing or eliminating capital investment and from increasing the efficiency of the air transportation system are enormous. However, the wide-spread adoption of such techniques throughout the United States would be such a radical departure from existing policies that resistance from several sectors of the aviation community could be expected. These institutional issues facing the United States before a peak-hour surcharge system could be widely imposed must be explored and in the long run may be more important than the economic issues involved.

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I. INTRODUCTION

Capital investment has been the traditional means of expanding airport capacity to meet the needs of the aviation community. However, as the costs of capital expansion have become increasingly prohibitive, more attention has been paid to alternate, non-capital-intensive techniques for accomodating increased demand. These alternatives range from those that are purely economic (e.g. charging appropriate runway usage fees, differentiated by time of day and by location) to those that are purely administrative (e.g. imposing maximum limits on the number of aircraft which may use specific airports or runways during a given time interval). These measures do not physically expand airport capacity, but they can postpone the need for physical expansion by promoting more intensive and more economically efficient use of existing capacity. To this extent, they are alternatives to capital investment.

These non-capital alternatives can be effective because of the characteristics of airport demand. First, hourly demand varies widely over the course of a typical day. This is true for virtually every airport in the world, large or small. Second, different users derive different values from operations at a particular airport based on their type of aircraft, the time of the day, the locality, etc. Third, operators of large commercial aircraft are severly constrained by runway length, strength of pavement, electronic instrumentation for airport approach and the like, while other users can operate, under most weather conditions, from unsophisticated and relatively inexpensive facilities.

These characteristics of demand (with the possible exception of the third) are not unique to airports but are common to other modes of transportation and certain public utilities. Thus, the basic economic concepts of peak-load

and efficient pricing, particularly marginal cost pricing, can be borrowed from Steiner's,[1] Hirshleifer's,[2] and Vickrey's[3] studies of public utilities and toll highways. However, the airport problem does have several peculiar aspects not covered in these early studies. As a result, efficient allocation of airport capacity has rapidly developed as a separate field of study since the late 1960s when the congestion problem first attracted sizable attention.

This report reviews the theoretical literature addressing the airport situation but does not discuss the sizable body of related materials dealing with problems of a similar nature for other modes of transportation. In addition to the theoretical analysis, the report reviews actual attempts to modify airport demand through economic charges and administrative quotas by the British Airports Authority, the Port Authority of New York and New Jersey, and the Federal Aviation Administration. Finally, the theory and the case studies are analyzed together and conclusions are drawn.

References for Section I

1. Steiner, Peter. "Peak Loads and Efficient Pricing", Quarterly Journal of Economics, Vol. 71 (1957), p. 585.

2. Hirshleifer, Jack. "Peak Loads and Efficient Pricing: Comment", Quarterly Journal of Economics, Vol. 72 (1958), p. 451.

3. Vickrey, William. "Optimization of Traffic and Facilities", Journal of Transport Economics and Policy, Vol. 1 (1967), pp. 123-136.

II. ALTERNATIVES TO CAPITAL INVESTMENT

The alternatives to capital investment can be grouped into three categories:[1]

Administrative Measures: Access to congested airports is restricted through administrative fiat. The restrictions may be selectively applied to specific categories of aviation, to certain periods of the day and to some but not all runways of an airport. The establishment of a "quota" system that limits the number of operations per hour is another form of administrative control. Airport curfews (usually imposed to deal with the night-time noise problem) are an extreme form of quota.

Economic Measures: Airport congestion is controlled through a pricing system which imposes higher charges during periods of high demand than at other times. This category can be further subdivided into measures that place a peak-hour surcharge on aircraft movements and measures that levy the surcharge directly on air passengers.

Hybrid Measures: Access is limited by a combination of administrative and pricing alternatives. A quota system limiting hourly operations could be combined with a peak-hour surcharge to assure that the available time slots are allocated efficiently.

Administrative Measures

The first-order and short-term effects of administrative alternatives are straightforward and predictable. As the number of flights at an airport is reduced by imposing a quota on the number of flights scheduled or by banning specific types of operations, congestion at that airport decreases. Because the relationship between airport demand and airport delay is very non-linear, a

carefully chosen limit on operations at a severely congested airport may drastically reduce delays without a significant reduction in the number of flights.* - Therefore, quotas and other administrative measures have been (and continue to be) particularly attractive as a means of dealing swiftly and effectively with airside congestion.**

In the long term, however, the impact and benefits of purely administrative measures are less clear because they offer no assurance that economic considerations will play a role in determining who will use a demonstrably (by virtue of it being congested) valuable facility or how this facility will be developed in the future.***

Once a user, for one reason or another, has been denied access to the airport, he has no way to prove that any given time slot is more valuable to him than to its present occupant. As long as the present occupant is willing to pay the fixed landing fee that the airport charges for the slot in question, everyone else is excluded. There is no opportunity to "bid up" the price of the time slot to reflect its value. Even where the time slots are periodically renegotiated there is no way, in the absence of a pricing mechanism, of ascertaining that the right to land at any specific time will go to those who most covet that right. In fact, it is not clear that reassignment contributes anything

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* Delay is generally proportional to $(1-\rho)^{-1}$, where ρ is the "utilization ratio" at the airport, i.e. the ratio between the number of operations at the airport (demand) and the capacity of the airport.

** In 1969, the FAA in the United States imposed hourly quotas on the scheduling of operations at the three New York City airports, O'Hare International in Chicago and Washington National. The quotas have been generally credited for strongly ameliorating the traffic congestion situation at these airports. Developments since 1969 have made it possible to eliminate the quotas at the J.F. Kennedy and Newark Airports in New York. However, the system continues to be in effect at the other three airports. See Section VI.

*** The purely administrative case is one in which rights for the use of the runways are offered and time slots are allocated either by executive fiat or through negotiations among users. In either situation, it is assumed that no explicit or implicit economic bidding for landing rights and time slots takes place.

to increasing the economic efficiency of the time slot allocations.

Administrative limitations on airport use, by keeping demand within acceptable bounds, may assure the relatively smooth operation of the facility and the lack of severe congestion into the foreseeable future. But with access to the airport restricted and with potential users unable to indicate the true value to them of future airport expansion, a false signal is conveyed to the government and the public alike. In effect, by arbitrarily constraining demand, artificial equilibrium conditions are created which, in the long run, are likely to distort the nature, quality and cost of the transportation service provided.

In summary, purely administrative measures, while effective and probably desirable in dealing with short-term congestion problems, tend to be strongly biased toward maintenance of the status quo when used over a protracted period of time. Because economic value is not fully considered in allocating time slots, current users cannot be displaced by others who may derive a higher economic value from the same time slots and the airport cannot obtain through economic mechanisms the information required to determine the need (or lack thereof) for capacity expansion or for an improved (or, for that matter, a reduced) quality of service.[2,3]

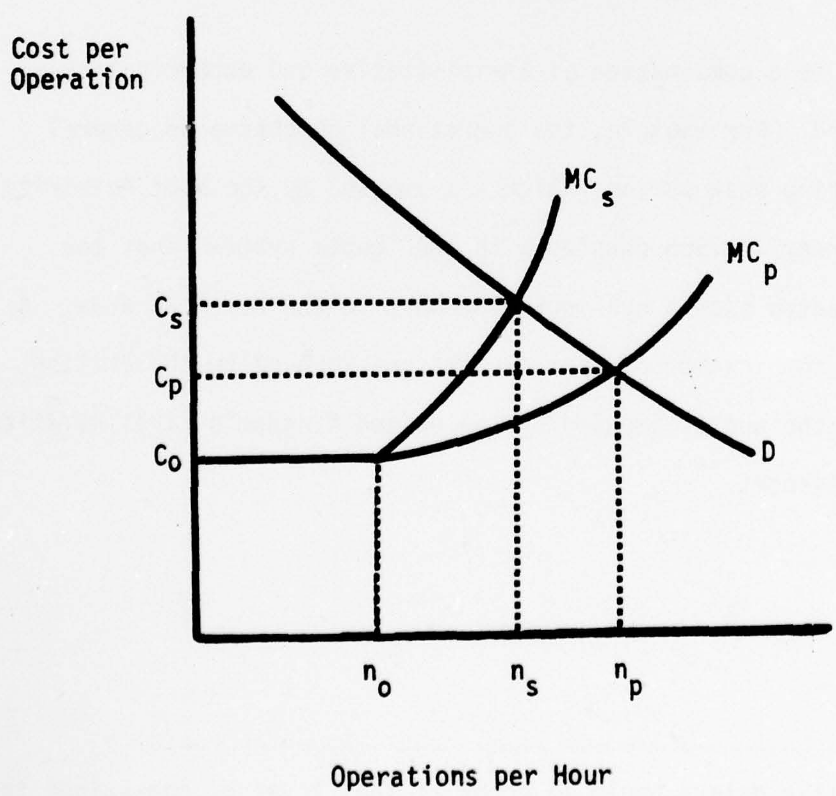
Economic Measures

The use of economic incentives rather than administrative controls could alleviate the long-term allocation and development problems if those incentives could be tied to the true costs and benefits of access to the airport. However, this is not a simple task because there are both private and social costs involved.[4]

Once the level of operations reaches the capacity of the airport, the addition of one more operation slows the flow of all operations, generating a delay for every aircraft attempting to use the facility. This additional marginal operator considers only his own delay in deciding whether or not to use the facility and fails to consider the impact on all other users. Thus the true social marginal cost deviates from and is higher than the private marginal cost. This can seen in Figure 1.

Figure 1

Airport Congestion Costs



The basic cost of an operation without delays is C_o. This cost remains approximately constant for each operation until the number of operations reaches perhaps 75 or 80 percent* of the maximum capacity of the airport (say at n_o operations per hour). Above that level of operations, significant delay costs are incurred with the marginal cost to society (MC_s) rising faster than the private marginal cost to the individual operator (MC_p). If only private costs (C_p) are assessed, operators will demand n_p operations per hour. If, however, the social costs (C_s) can be assessed, demand will fall to n_s. At this point, social costs are covered and congestion is decreased. The difficulty lies in determining the social costs and adjusting operating fees to reflect them.

Hybrid Measures

Hybrid measures use a combination of administrative and economic techniques to control demand. For example, the operational surcharge on general aviation movements during peak periods which was imposed by the Port Authority of New York and New Jersey in 1968 coupled with the "quota system" that the FAA imposed in 1969 created such a hybrid environment in the New York area. A similar example is the combination of economic charges imposed by the British Airports Authority and the quotas imposed by the United Kingdom's Civil Aviation Authority at Heathrow Airport.**

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*The fact that appreciable delays begin to occur at that level of operations is due to the non-uniformity in the schedule of airport movements and to the numerous random deviations from that schedule.

**See Section VI for details.

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1. Rose, Kenneth and Hamilton, G.B. "An Investigation of the Effects of Airport Landing Fees on Airport Congestion", Transportation Research Forum Proceedings, Vol. XVI, No. 1 (1975), pp. 175-186.

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3. Pulling, Ronald E. Economics of Capacity (Delay Costs) Peak-Load Pricing, Federal Aviation Administration, Draft Report (1972).

4. Due, John F. and Friedlaender, Ann F. Government Finance (5th Edition), Richard D. Irwin, Inc., Homewood, Illinois (1973).

III. QUANTITATIVE MODELS OF THE RUNWAY PRICING PROBLEM

Several transportation economists have already constructed preliminary mathematical models for the analysis of the runway pricing problem. Those of Park (1971),[1] of Fitzgerald and Aneuryn-Evans (1973)[2] and of de Neufville and Mira (1974)[3] have attracted most attention. All three are somewhat similar in structure and assumptions and examine variations or extensions of the same basic case. Consequently, only Park's model will be discussed in detail.

Mathematical modeling makes an important contribution to our understanding of the airport congestion and pricing problem by quantitatively formulating ideas that are drawn out and somewhat ambiguous when presented verbally. Mathematical manipulation also leads to new insights on the relationships among the variables of the problem which in turn may lead to significant policy improvements, especially in the heavily regulated environment of air transportation. However, current models are based on <u>a limited version</u> of the "real world." Most of the complexities present in practice have been suppressed at this early stage for mathematical tractability. This limits the applicability of the model's conclusions and is probably the main reason why policy-makers and administrators concerned with congestion problems have proceeded in a pragmatic rather than analytic fashion to date.

The Park model for determining congestion tolls at commercial airports explicitly or implicitly makes the following simplifying assumptions:

<u>Uniform Demand</u>: Time variations in the demand rate are disregarded.

<u>Single Market</u>: There is only a single destination (and a single origin) for all outgoing (and incoming) flights at the airport of interest.

<u>Homogeneous Traffic</u>: Only airlines use the airport and all aircraft are of the same size and have identical operating costs per unit of time.

<u>Competitive Market Structure</u>: No airline or airlines monopolize or oligopolize the market. This does <u>not</u> preclude the case of regulated (fixed) ticket prices.

In addition, all variables in the problem are assumed continuous.

The Basic Model

The objective of the Park Model is to identify policies which maximize the net social benefits of the transportation service provided at the airport for society as a whole. Stated mathematically, the model maximizes*

$$S = V - C \tag{1}$$

where

S = the net benefits to society

V = the total value of the transportation service, and

C = the total cost of providing the service.**

The total value, V, of the transportation provided is a function of the

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* The optimization problem is subject to a number of constraints imposed by physical considerations (e.g. the finite capacity of the aircraft) and by economic or regulatory factors. <u>Different regulatory environments impose different constraints</u>.

** This presentation of the basic economic model varies to some extent from that of Park to make the notation consistent with that used later in this review.

number of passengers, N, and of the number of flights, n.* Although the exact form of the function is not really known, some of its properties are (or can be rationally inferred). Thus, V can de defined as

$$V \triangleq V(N,n) \tag{2}$$

with the properties

$$V_N \triangleq \frac{\partial V}{\partial N} > 0 \tag{3}$$

$$V_{NN} \triangleq \frac{\partial^2 V}{\partial N^2} < 0 \tag{4}$$

(The value of an additional passenger trip, while holding the number of flights constant, is positive — $V_N > 0$ — but the increment of additional value becomes smaller the more trips that are taken — $V_{NN} < 0$.)

Likewise

$$V_n \triangleq \frac{\partial V}{\partial n} < 0 \tag{5}$$

$$V_{nn} \triangleq \frac{\partial^2 V}{\partial n^2} > 0 \tag{6}$$

(If the number of passengers is held constant, value decreases as the number of flights increases — $V_n < 0$ — because delays increase. The more the flights increase, the faster delays increase and the faster value decreases — $V_{nn} > 0$.)

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* It is convenient to think of S, V, C, N, and n as net benefits, value, total costs, number of passengers and number of flights <u>per unit of time</u> (although the above quantities remain invariant in time because of the demand uniformity assumption).

Finally -

$$V_{Nn} \stackrel{\Delta}{=} \frac{\partial^2 V}{\partial N \partial n} < 0 \qquad (7)$$

(The more passenger trips are affected by delay, the more value decreases — $V_{Nn} < 0$.)

The total cost, C, of providing transportation service can be written as

$$C = n \cdot c = n \cdot c(n) \qquad (8)$$

where c(n) is the cost per flight when there are n flights. Because cost increases with delay, and delay increases with more flights,

$$c' = \frac{dc}{dn} > 0 \qquad (9)$$

and

$$c'' = \frac{d^2c}{dn^2} > 0 \qquad (10)$$

Although no specific functional forms for V and C have been postulated, the analytical approach and the use of the mathematical model can still produce useful results derived from the basic properties of the value and cost functions.

Before going further, it is necessary to consider a specific regulatory environment with its applicable constraints. Park has examined two possible situations. In the first, ticket prices are not regulated but determined by competition. In this case, a congestion toll can be assessed against the air-

lines or the passengers creating the congestion with the same final result because the passenger is the one who ultimately pays. If the fee is assessed against the airlines, they will pass it on to the passengers traveling during the congestion toll period through a fare increase. Passengers traveling at off-peak periods or using uncongested airports will not pay congestion costs because competitive pressures in these markets will prevent the airline from spreading the congestion costs throughout the system.

In the second case, ticket prices are fixed by the government or other authority at somewhat above the competitive level. Competition among airlines is then based on schedules (i.e. frequency of flights) and not on price.[4] This has two effects. To the extent that the increased frequencies exceed airport capacity, congestion costs are increased. Also, how the congestion toll is assessed now makes a difference. As in the unregulated environment, it could be assessed against the passengers causing the congestion. But, unlike the unregulated situation, a toll assessed against the airlines could not be passed directly to the passengers causing the congestion without a change in regulatory policy.

Traditionally in the regulated airline environment, costs are averaged over the entire system and fares based on these average costs. As a result, a toll assessed against an airline for congestion at a particular airport would be spread among all the passengers using the system. Passengers traveling during a peak period at a congested airport would pay only a small fraction of the congestion toll assessed against the airline and have little incentive to change their travel patterns.

Although the domestic and international air transportation systems as they

exist today are based on fixed ticket prices, only the flexible ticket case will be developed in detail to illustrate the general approach followed. Because the analysis of the fixed ticket case is considerably more complicated mathematically and would call for a much lengthier discussion, its description is limited to the conclusions drawn.

Flexible Ticket Price Model

If a congestion toll of F dollars is imposed on each flight contributing to the congestion, the fixed cost per flight is equal to c + F. If the ticket price is denoted by p, then

$$n(c + F) = pN \tag{11}$$

(Total costs equal total revenues.*)

With the price of the ticket set at p, the level of passenger demand can be determined from the equation

$$V_N = p \tag{12}$$

(Equilibrium is reached when the value of the trip to the marginal passenger, $V_N\left(= \frac{\partial V}{\partial N}\right)$, is exactly equal to p.)

Finally, if A is the number of seats in the standard aircraft, the physical capacity constraint can be expressed as

$$\frac{N}{n} - A \leq 0 \tag{13}$$

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*As in all such economic analyses, it is assumed that the cost c per flight also includes the normal — "reasonable" — return on investment required by the airlines.

(The number of passengers per flight cannot exceed the seating capacity of the aircraft.)

The optimization problem can now be stated as

Maximize $S = V - C = V(N,n) - nc(n)$ (From Equation 1)

subject to the constraints

$n(c + F) = pN$ (From Equation 11)

$V_N = p$ (From Equation 12)

$\frac{N}{n} - A \leq 0$ (From Equation 13)

Solving this problem in functional form,* at optimality the condition <u>must</u> hold that

$$F = nc' - V_n = n\frac{dc}{dn} - \frac{\partial V}{\partial n} \tag{14}$$

(The congestion toll imposed on each flight must be equal to the increased operating costs imposed on all other flights due to the increased delay caused by the flight minus the value of the additional flight. But in the congested case V_n is negative from Equation 5.)

<u>Optimality cannot be achieved unless each additional (marginal) flight at the airport pays for all the additional costs it imposes on passengers and airlines. Thus, a congestion toll not only contributes to a socially desirable result but is necessary to reach such a result.</u>

A second condition for optimality is

$$A = \frac{N}{n} \tag{15}$$

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* Both Park and de Neufville and Mira use the Kuhn-Tucker conditions to solve this problem. However, it can also be solved by traditional calculus techniques.

(At optimality, airplanes must fly full.)

This condition is hardly surprising in view of the simplifying assumptions made in the model — perfect competition, no time variation in demand, one origin and one destination. This demonstrates the limitations of existing analytical methods which implicitly assume that passenger demand from destination to origin is identical in every respect to demand in the opposite direction and that airplanes never have to return with partial loads to pick up full loads at the origin.

Fixed Ticket Price Model

In this analysis ticket prices are fixed by regulatory agencies at something above the competitive level (as seems indeed to be the case in practice). However, airlines are still competing in quality of service: larger and faster aircraft, better food service, more comfortable seats and the like. The main aspect of service competition is flight frequency. "That is, they [the airlines] add flights until load factors are forced down to break-even levels."[5] Thus, low load factors are the rule, passengers are flown inefficiently, more flights are operated than necessary and the excessive number of flights generates excessive congestion at airports.

Both Park and de Neufville and Mira show that this situation can be ameliorated through the imposition of a congestion toll. However, it makes a difference whether the toll is imposed directly on each flight (i.e. on the airlines) or is collected in the form of surcharge from passengers. With the fares fixed, airlines cannot pass on the cost of the toll to the passengers (in contrast to the flexible ticket price case).

The mathematical analysis of congestion tolls on the airlines as compared to surcharges on the passengers is quite complicated.* However, the basic outline of the arguments for the two alternatives is straightforward.

Airline Tolls — If a congestion toll is assessed on the flight rather than on the passengers, the cost of operating a flight increases. Because costs and revenues must be in equilibrium (Equation 11), the airline must increase revenues to offset increased costs. However, the regulatory environment makes it difficult to raise fares. Therefore, the airline increases revenues by increasing the number of people on each flight. It flies fuller planes. Because the passengers do not pay the price increase, their demand is constant. The net result is the same number of passengers accommodated on fewer, fuller flights. If F is large enough, the airlines will fly full planes, maximizing efficiency and minimizing congestion.

Passenger Surcharge — If the congestion toll is directly assessed on the passengers as a surcharge (H), the situation changes. Now the perceived cost of the transportation increases for the passenger and demand will fall. But as far as the airlines are concerned, H does not affect the costs of a flight and they will continue to operate at the same inefficient break-even load factor. Although the number of flights will decrease as demand decreases and delay is less severe, the imposition of the passenger surcharge in a

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* See de Neufville and Mira for details.

fixed-ticket price environment cannot lead to an efficient solution.[6]*

In conclusion, both Park and de Neufville and Mira point out that in a fixed-ticket price environment, it is always better to impose a congestion toll and impose that toll on flights rather than on the passengers.

> Landing fees on aircraft are socially desirable and head taxes are not. We would thus endorse the policy of higher landing fees at peak hours instituted by the Port Authority of New York and New Jersey in 1968, and more recently by the British Airports Authority. The departure taxes on passengers such as those instituted by several American airports from 1972 on or the International Departures Noise tax in Paris do not optimize the air transport system whatever their immediate convenience to the taxing authorities may be.[7]

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*The airline's response is constrained by the model's assumption of a fixed-capacity aircraft. In reality, an airline faced with a congestion toll charged to its flights would still increase load-factor. But at some point it would introduce larger planes rather than further decrease frequency. Thus, the model overstates the reductions in frequency and in delay.

Conversely, if the surcharge were placed on the passenger, demand would fall. But at some point the airline would switch to smaller planes rather than further decrease frequency. Again, the model overstates the reductions in frequency and in delay.

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5. Supra, note 1.

6. Ibid.

7. Supra, note 3.

IV. MEASUREMENT OF TIME-DEPENDENT CONGESTION COSTS

Marginal delay costs are defined as the total congestion costs that an additional user of an airport imposes on other users of the facility. The computation is based on the theory that

> during a period when an airport is continuously busy, each user imposes some delay on all following users until the end of the busy period. That is, an additional user shoves those following him one space back in the queue, and the effect persists until the queue dissipates.[1] (Emphasis added.)

These costs are a function of the type of operation, the time needed for each type of operation, the mix of different types of operations, the costs of delay for each type of operation and the total number of operations during the busy period.* That is, for a particular type of use, j, at time, t, the marginal delay cost, D_j, is

$$D_j = s_j(p_1Nc_1 + p_2Nc_2 + \dots + p_kNc_k) \tag{16}$$

or

$$D_j = s_jN \sum_{i=1}^{k} p_ic_i \tag{17}$$

or

$$D_j = s_jN\overline{c} \tag{18}$$

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* The discussion draws heavily on the pioneering work of Carlin and Park, based on their 1969 analysis of congestion delays at the New York airports.[1]

where

i = an index for each type of operation (an air carrier landing and a general aviation landing are each different types of operations)

k = the number of different types of operations at the airport

s_i = length of time in minutes needed to provide service for an operation of type i

N = total number of operations that take place from time t until the end of the busy period

p_i = proportion of total operations of type i at time t

c_i = cost per minute of delay for each type of operation i

$\bar{c} = p_1c_1 + p_2c_2 + \ldots p_kc_k$ = average total cost per minute of delay for the mix of operations at the airport at time t.

In other words, the total marginal cost of an operation of type j at time t equals the delay caused by that operation (the time required to service that operation, s_j) times the cost per minute for all the aircraft behind operation j in the queue.

Now, if

$$N = \frac{B}{\bar{s}} \tag{19}$$

where

B = total time from t to the end of the busy period

$\bar{s} = p_1s_1 + p_2s_2 + \ldots + p_ks_k$ = average length of time needed to provide service to a user for the mix of operations at the airport at time t

then

$$D_j(t) = \frac{s_j \cdot \bar{c} \cdot B}{\bar{s}} \tag{20}$$

which makes explicit the dependence of the marginal delay costs on the time of day, t. This is necessary because the length of a busy period, B, changes with the time of day (B is naturally longer during peak-demand periods). Also, the average delay cost per minute, $\bar{c}$, and the average duration of service time, $\bar{s}$, are functions of the traffic mix, p_i, which changes with the time of day.

Equation 20 is valid even where the service times and the delay costs for each type of operation are random variables with known probability density functions, $f_{s_i}(s)$ and $f_{c_i}(c)$, as is the case in practice. All that is needed is to modify the definitions of s_i and c_i to be the expected service time and the expected delay cost per minute for operations of type i.

Carlin and Park used actual measurements of B, $\bar{s}$, $\bar{c}$, and s_i obtained at New York City's airports to compute the marginal delay costs $D_i(t)$ through Equation 20. They identified four types of operations (air carrier landings, air carrier takeoffs, general aviation landings, and general aviation takeoffs). For each type of operation, they estimated $D_i(t)$ for each of the 24 hours of the day. For instance, they claimed that the marginal delay costs imposed by an air carrier landing between 4 and 5 p.m. at La Guardia Airport amounted to $963 in 1967, whereas the marginal delay costs associated with a general aviation takeoff during the same hour were $443.[2]

The work of Yance, conducted during approximately the same period (1967-1969) as Carlin and Park's, takes a different approach.[3] Yance's main interest lies in determining the relative landing fees for general aviation and commercial aircraft (or, in general, the relative magnitude of landing fees for different types of airport users). Yance's basic premise is that the time for a particular movement has an "opportunity cost" because "an increase in the movement rate of one type must be accompanied by a decrease in the movement rate of another type" if the average delay at an airport is not to be increased. He concludes that a rational way to determine the relative magnitude of the opportunity costs associated with two different types of operations is to determine what could be called the "rate of substitution" of one type of movement for the other. This rate of substitution is the ratio of the service times for the two types of movements. Thus the relative landing fees for different types of operations, i and j, should be in the ratio of s_i to s_j. This is the same result as that obtained by Carlin and Park because, from Equation 20

$$\frac{D_i(t)}{D_j(t)} = \frac{s_i}{s_j} \tag{21}$$

Therefore, once the marginal delay costs, $D_j(t)$, for one type of user, j, have been determined, the marginal delay costs for different users ($i = 1, 2, \ldots k;\ i \neq j$) can be determined through Equation 21. Yance has correctly pointed out by reference to the <u>Airport Capacity Handbook</u>[4] that the ratios s_i/s_j change with the overall mix of traffic at different airports. This is because the service time required for

the movement of a given aircraft often depends on the type of aircraft that has immediately preceded it and this, in turn, often depends on the aircraft mix at a particular airport.*

The mathematical tools for computing marginal delay costs have greatly improved since the late 1960s. Whereas Carlin and Park had to resort to imprecise and complicated data sources to estimate the variables** necessary to compute $D_j(t)$, it is now possible to compute marginal delay costs by using theoretical considerations and a minimum amount of readily available data. For instance, Hengsbach and Odoni have recently developed a package of computer programs that can accomplish this at little cost and with considerable precision.[5] Their approach is based on the earlier theoretical work of Koopman on time-dependent queues.[6] Using only information on the demand rate, the traffic mix and the service capacity at a given airport, numerous queuing statistics can be computed as a function of time of day. Marginal delay costs can then be estimated by modifying airport demand to include "additional users" at the desired times of the day.

The technique has not yet reached the level of refinement where marginal delay costs for different types of movements (e.g. an air carrier departure, a general aviation landing, etc.) can be computed. Instead a single marginal delay cost is obtained for an "average" additional operation taking place at any specific time, t. From this, however, it

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* As an example of this, take the case of the landing of a small general aviation aircraft under IFR conditions. If the preceding landing aircraft is also a general aviation airplane, the required in-trail separation between the two aircraft is 3 n. miles. If the preceding aircraft is a wide-body jet, a 5 or 6 n. mile separation is required due to the wake-vortex danger.

** It is especially difficult to obtain field data about the duration of busy periods, B, at different times of the day. These difficulties were described in detail by Carlin and Park.

is then possible to compute "operation-specific" marginal delay costs from the relative length of service times for different types of operations, through Equation 21.

The results of the various studies on delay costs can be summarized as follows.

First, the marginal delay costs due to operations at peak traffic hours are sizable in absolute terms. Carlin and Park estimate a marginal delay cost of approximately $1,000 for each air carrier operation at La Guardia during the peak afternoon hours (for 1967 traffic levels). Hengsbach and Odoni estimate the marginal delay cost for a similar operation at Boston's Logan International Airport (for 1970 traffic levels) at $175. About 50% ($500) of the Carlin and Park figure is the imputed cost to airline passengers of the extra delay, whereas the $175 figure of Hengsbach and Odoni does not include any passenger delay costs. This explains part of the difference between the two figures. In addition, La Guardia is a much more congested airport than Logan International (and was especially so in 1967).

Second, the variations in marginal delay costs within the course of a day are very large. Both Carlin and Park and Hengsbach and Odoni found an approximate 10 to 1 ratio between the size of marginal delay costs during the peak evening hours and the same costs during the "slack" mid-day (11 - 12 a.m., noon - 1 p.m., etc.) hours. That is, marginal delay costs during low demand periods amount to only about 10% of the peak-hour marginal delay costs.* In general, the exact relationship between peak and off-peak costs will depend

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* During the very low utilization hours at major airports (usually between 11 p.m. and 7 a.m.) marginal delay costs are equal to zero, for all practical purposes.

on the detailed shape of the demand profile for the 24-hour period.

Third, Carlin and Park estimated that the marginal delay costs for general aviation movements are about 50% of the equivalent costs for air carrier movements. Yance found that this percentage can be anywhere from 42% to 85%, depending on the mix of traffic at each airport.

Fourth, current U.S. landing fees, which are solely based on aircraft weight, rarely exceed $150 for a medium size commercial jet (e.g. a B-727) and $20 for general aviation aircraft. These fees do not vary with time of day. Thus, the adoption of a landing fee system based on marginal delay costs would be a radical departure from existing practices and prices. Immediate effects would be a sizable increase in landing fees for peak-hour operations and an even steeper increase (percentage-wise) in landing fees for general aviation aircraft using major runways at major airports during peak traffic hours.

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6. Koopman, B.O. "Air Terminal Queues Under Time-Dependent Conditions", Operations Research, Vol. 20, No. 6 (November-December, 1972), pp. 1089-1114.

V. PROBLEMS IN APPLYING THE THEORY

The basic arguments in favor of a time-varying structure of airport fees and some general policy guidelines (for example, fees should be proportional to the magnitude of the marginal delay costs) for setting these fees are well understood. As discussed in Section IV, methods exist to accurately compute delay and marginal delay costs for any given capacity-to-demand relationship at any given airport. Current pricing policies at congested airports are far from optimal from the standpoint of economic efficiency.

The next natural step should be to establish price structures that specify airport usage fees by type of operations and by time of day. Such fees would maximize the net benefits that society derives from existing airport facilities. Unfortunately, there are a number of factors that immensely complicate the determination of such a price structure, ranging from analytical difficulties to questions of policy toward specific segments of aviation. (There may be valid policy reasons not to seek economic efficiency as a primary goal.)

Determination of Equilibrium Prices

Although models exist to estimate the marginal delay costs associated with any given flight demand and capacity profiles, there is no guarantee (in fact, it is highly unlikely) that setting congestion tolls equal to the marginal delay costs under any given status quo will lead to equilibrium conditions. If a high fee equal to the current marginal delay costs were imposed on operations conducted at peak traffic hours at a specific airport, at least some of the peak hour operations would move to off-peak hours to avoid the surcharge. This would lower marginal delay costs at peak demand periods, and conversely raise marginal delay costs at off-peak periods. Runway usage fees would then

have to be readjusted (lowered at peak hours and increased at off-peak hours) thus luring back some of the operations that were previously driven away. This sequence could continue ad infinitum unless some means of computing equilibrium prices exist.

This problem has been succinctly described by Carlin and Park.

> One of the difficulties in making estimates of marginal costs with the intention of using them as prices is to allow for the effects that the prices themselves will have on runway use. Use of the full marginal delay costs, for example, to determine peak hour surcharges for the use of runways would not represent equilibrium conditions because their use would reduce the number of airplanes using the airport, thereby reducing marginal costs and hence the prices that should be charged. If instituted immediately, such a pricing system would be less than optimally efficient by overly reducing traffic. It might even be dynamically unstable, in the sense that costs recomputed in succeeding periods and used as prices might not converge to an equilibrium level. This would be the case if, after full marginal delay cost prices were imposed, traffic decreased so much that marginal costs fell below the level of current landing fees. Using these lower costs as prices during the following period would result in traffic above current levels, and undamped oscillations in prices and traffic would ensue.
>
> Using full marginal costs as prices without adjustment would clearly be unwise. On the other hand, to determine analytically a set of equilibrium prices would be an impossible task. <u>To do so, we would need to know with some confidence and precision what the pattern of traffic would be under different sets of prices. We do not.</u>[1]* (Emphasis added.)

In short, there is no information on the <u>sensitivity of airport demand to changes in runway usage charges</u>. And without this information, the effects of any specific price structure on the pattern of demand for airport operations cannot be predicted. None of the mathematical models reviewed considers demand elasticity, even at the theoretical level. They assume uniform demand which ignores the relationship between the number of operations at peak and off-peak periods and the respective levels of runway charges during these periods.

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* Terminology has been slightly edited for consistency.

This is one of the most fundamental deficiencies of the analytical work that exists to date.

Network Effects

The air transport system requires a complex network of facilities which are often interdependent. Congestion at any one airport cannot be considered in isolation but must be analyzed with due consideration to congestion at all other airports with which this airport is linked. It is conceivable that pricing systems developed separately for two interconnected airports would cancel out each other's intended beneficial effects. Ideally, therefore, airport price structures should be determined for networks of airports rather than for each single airport in isolation, which requires a degree of complexity far beyond current analytical models and techniques.

On the other hand, one can argue that no major airport receives an overwhelming fraction of its flights from any single source and, consequently, that the interdependence is loose enough to permit examining each airport separately. Neither position can be proved or disproved at the present time.

However, the interconnection of airports cannot be dismissed so easily from an individual airline's point of view. Because of the need for high aircraft utilization, existing airline scheduling patterns are relatively insensitive to isolated changes in landing fees. Changing the arrival or departure time for a given flight at any particular airport would mean changing flight times at all other airports that the aircraft serves— not to mention the "ripple effects" on all the connecting or "feeder" flights by other aircraft which may have been set to conform with the first aircraft's schedule.

However, this is consistent with the concept of marginal cost pricing. The example implicitly states that an airline may be willing to pay a high fee for the privilege of having its aircraft land and take off at a particular time at a specific airport. Another airline or a general aviation user who does

not place such a high value on the time of a flight to the same airport would not-pay the high fee but would use a different facility or fly at a different time. The result would be less congestion and improved utilization at the airport in question.

However, the main point cannot be ignored: to predict an airline's response to a time-varying price structure at a particular airport, the repercussions of each possible change on the complete schedule of the airline must be considered. It is unlikely that an airport planner or airport economist can make these estimates.* Therefore, knowledge about an airline's elasticity to runway fee changes will probably be uncertain for a long time to come. And, as a result, the impact of price structures on an airline's behavior can be determined in only an approximate manner rather than be estimated from specific hard information.**

Recovery of Facility Costs

The analysis of time-varying runway fees that would maximize social benefits did not place any minimum acceptable limits on the total revenues that airport authorities should collect from such fees. Yet such minimum acceptable limits do exist in practice because the airport must recover at least some of its maintenance, operation and construction costs. Although the degree of expected recovery varies widely not only from one country to another but also from location to location within countries (especially in the United States),

*It is even unlikely that the scheduling staff of an airline can perform this task with any degree of accuracy.

**It is important to note that this statement applies primarily to scheduled airline flights. Charter and general aviation movements which are not as sensitive to system effects should be more responsive to price changes. This is borne out by the case studies in Section VI.

there is a basic policy in developed countries that major commercial airports must be more or less self-supporting economically.* This has several consequences for pricing structures.

First, the minimum amount is usually substantial in absolute terms. It is, therefore, entirely possible that the airport's basic need could exceed the amount collected under a marginal delay cost pricing policy designed to optimize the social utility of the airport. Optimality may in fact be precluded because the landing fees needed for financial support are too high and eliminate flights that would have taken place if charged only for marginal delay costs.

Second, it is very difficult to determine what the long-term costs are that must be attributed to and recovered from airside users. For instance, if one of the airport's goals is to accumulate resources for future expansion and improvements, it must know what such future changes will be and what they will cost. However, in most cases this information is unknown because future expansion plans are contingent on future airport demand (which in turn is affected by the very set of usage fees that have to be determined). In the United States this difficulty is bypassed, as a rule, by requiring recovery after the fact; after a facility has been built, its users pay fees

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* In Great Britain the mandate for self-support is spelled out clearly with specifications of annual rates of return,etc. In France and Germany, airports strive for self-sufficiency but usually receive heavy, direct subsidies from the government. In the United States, statutes vary widely from location to location, but the net effect is that airports are usually self-supporting, at least in the sense that they pay for their own construction, maintenance and operation costs. This is not to say that airports do not receive very substantial indirect subsidies. In the United States, for instance, these subsidies include low-cost funds from Federal, state and local governments; assumption of all air-traffic-control-related expenditures by the FAA; exemption from land-use rents or taxes by cities or local governments, etc.

that amortize the cost of the facility over the estimated span of its useful lifetime.*

Third, the proper way of allocating facility costs among users is very controversial. Presumably, if marginal cost pricing is to be the norm, each user must pay for the additional "wear and tear" (marginal short-term costs) and the additional construction costs (marginal long-term costs) caused by his use of the airport. But, of course, it is practically impossible to really determine what these marginal costs are.** The present system of computing landing fees, primarily based on aircraft weight, can be viewed as an attempt to deal in a practical way with the problem of charging for marginal facility costs. Marginal facility costs and related issues have been discussed at length by Eckert,[2] Levine,[3] and Little and McLeod[4] and will not be considered further.

There is, however, another interpretation of weight-based fees which, although not central to the discussion in this section, is directly related to airport congestion. Airside facilities have very high initial (i.e. construction) costs, but once the runways and taxiways are constructed, the costs caused by an additional operation at the airport are close to zero. As long as the facility is underutilized, it is to the airport's advantage to invite additional users to the facility, increasing revenues. They do this through a discriminatory price structure based on willingness or ability to pay. In this

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* Unfortunately, this method of cost recovery provides no advance indication of what additional facilities and how much expansion present users would be willing to pay for. The user is confronted with the increased costs only after new facilities have been built.

** As an example, the favorite argument of general aviation proponents in this respect goes something like this: "Why should a small private airplane landing on a 10,000 foot runway pay for all 10,000 feet? This airplane only needs 3,000 feet. The only reason for the extra 7,000 feet is that air carriers need it. Let them, then, pay the full costs of the extra 7,000 feet plus the cost of the reinforced pavement, extra width, etc." To which the air carriers usually respond: "In this case, why do you use the 10,000 foot runway at all?" This is only the beginning of a prolonged and often heated debate.

context, aircraft weight is a proxy for willingness or ability to pay: a light, general aviation aircraft whose operator cannot presumably afford a large runway fee is, in this way, charged much less than a commercial jet.

While this pricing policy may be appropriate for underutilized and uncongested airports, it is counterproductive for congested facilities. By pricing the facility according to aircraft weight, it effectively encourages those users who are less willing to pay full costs and who, at least on the average, contribute less "transportation value" per operation to society as a whole. In fact, the only deterrent to airport use under present weight-based systems is the prospect of delay at a congested airport. Thus, a user who is able to tolerate his own delay will use the airport without considering the delay costs that he imposes on others.*

Reluctance to Change

Pricing based on marginal delay costs, in its pure form, charges each airport user with the costs that user imposes on others. An airplane landing at a busy commercial airport during a peak traffic hour could be charged $1,000 or more, depending on the level of congestion and the mix of traffic at the airport.**

Such a pricing system clearly does not consider the "ability to pay" of the user. Whereas a $1,000 charge may be a small percentage of the total revenues of an inter-continental flight of a B-747 jet, it would exceed the total revenue of most commuter carrier flights. In other words, marginal delay cost pricing could result in a schedule of charges which may be hard (or impossible) for certain kinds of aviation or types of flights to pay.

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* As discussed in Section II.
** As discussed in Section IV.

General aviation flights would feel the impact of marginal delay cost pricing most severely. Flights of regional and "third level" (commuter) carriers and, to a lesser extent, short-haul flights by trunk carriers would also be strongly affected. In short, marginal cost pricing would most likely eliminate flights for which airport fees represent a sizable percentage of the value of the flight to the aircraft operator.

Although this is the purpose of marginal cost pricing — to eliminate those to whom the value of using the airport is less than the costs they impose on others — the imposition of fees without consideration of ability to pay is such a drastic departure from prevailing practices that it may appear to be discriminatory and unfair. Those users who have relied on the traditional low cost policies and who have developed vested interests in their continuation are the major impediment to the adoption of marginal cost pricing at congested airports.

Likewise, airport administrators can hardly be expected to adopt in one single step pricing policies which are so different from the ones they have been accustomed to and with which they have had long experience. Their reluctance in this respect could be increased by apprehension regarding the exact nature of short and long-term reactions to the new policies by the various aviation interest and pressure groups. In addition, the inability of analysts and of economic theory to determine in advance equilibrium pricing schedules and to forecast the precise effects of marginal cost pricing on airport usage raises some financial risks that could result from a departure from present practices.

To evaluate the potential economic (and political) risks and the possible benefits of peak hour pricing, actual experience and not theory is needed.

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VI. PEAK HOUR PRICING IN PRACTICE

Although the theory of peak hour pricing as a tool to spread demand away from periods of congestion has received a great deal of attention in the economic and technical literatures, the theory has only been applied in a few instances, and only a fraction of these experiments have been documented. Fortunately, two of the best documented cases are airports which have imposed peak hour charges to alleviate congestion. Of these, the experience of the British Airports Authority at Heathrow is the most complicated and least understood in this country. The other airport application is the peak hour general aviation surcharge imposed by the Port Authority of New York and New Jersey.

The London Case Study

In the United States, most commercial airports are owned and operated by local governments or authorities. Few control more than one facility. In contrast, the British Airports Authority (BAA) is the major airport operator in the United Kingdom.

The Role of the British Airports Authority

The BAA is a nationalized service enterprise established in 1965. It owns and manages seven of the United Kingdom's 27 major airports (Heathrow, Gatwick and Stansted, in southeast England near London; and Prestwick, Edinburgh, Aberdeen and Glasgow in Scotland). These seven airports handle 75% of the United Kingdom's passenger and cargo traffic.[1]

Under legislative mandate, the government expects the BAA to pay taxes and to earn an average return on its net assets. For the nine year period 1965/1966* to 1974/1975, the average return has been 13.28%. The target for 1973/1974 to 1975/1976 is 15.5%. This was exceeded the first year (16.15%), but the return dropped to 11.47% in 1974/1975.[2]

During 1974/1975 the BAA's overall operating profit was $20,644,000. (All numbers in this section of this report are based on a conversion rate of $2 to the pound.) The profits from Heathrow and Gatwick were $21,438,000 and $836,000 respectively, offsetting the loss of $1,630,000 at the other four airports operated by the BAA at the time.[3]

All airports lost money on traffic-related operations — provision of fire and ambulance equipment; construction and maintenance of runways, taxiways and aprons; the construction and maintenance of passenger terminal areas; and operation of ramps, gates and apron areas. (In the U.S., these facilities are usually operated and controlled by the airlines under long term leases with the airport operator.) The revenues derived from landing fees and apron, ramp and other service charges were insufficient to offset the operating costs.

In contrast, all airports made money on commercial operations — trading concessions, rents, services and admission fees. At Heathrow alone, commercial operations netted $22,644,000 while traffic operations lost $1,206,000. In 1973/1974 both produced profits of $20,524,000 and $5,184,000 respectively.[4]

<u>The Role of the Civil Aviation Authority</u>

Air traffic control and terminal navigation are the responsibility of the National Air Traffic Services (NATS), a part of the Civil Aviation Authority

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* BAA's fiscal year runs from April 1 of one year to March 31 of the next.

(CAA). The CAA is roughly equivalent to a combination of the United States Federal Aviation Administration and Civil Aeronautics Board. But unlike U.S agencies, the CAA is an independent public body, separate from the government. Under its enabling legislation, the CAA is expected "to recover, as soon as possible, the whole of its costs, and a return on capital....The Authority should formulate its financial plans with a view of dispensing with [government subsidy] by 1977/1978."[5]

In 1974/1975, the CAA lost $79,288,000 on operations before subsidy. Enroute navigation services accounted for $54,666,000 of the loss. Although the CAA would like to increase fees to offset this loss, it cannot because the enroute fee system is subject to international control through Eurocontrol. The CAA does control fees for terminal navigation services, however, and these can be expected to be increased to offset a $10,610,000 loss for these services in 1974/1975.[6]

Heathrow Operations

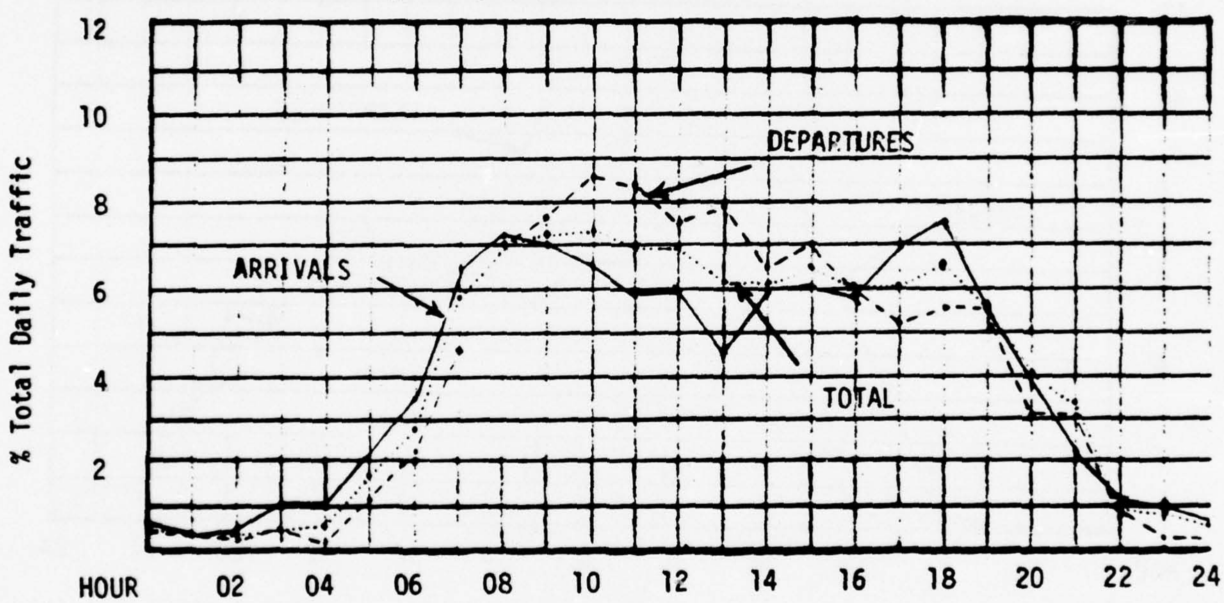
Compared to other major airports of the world, Heathrow ranked 5th in air transport operations (267,726), 14th in aircraft movements (289,937), 6th in terminal passengers (20,337,289), and 4th in cargo tonnage (460,827 metric tons) in 1974/1975.[7]

Because of its high traffic levels and rather limited facilities (two parallel main runways with a shorter, interfering diagonal runway), Heathrow operations experienced air traffic congestion many years ago. In response, the air traffic control authority (now NATS) imposed operational quotas (a "slot" system) during the 1960's. Although the quotas have been increased over the years, they are still basically determined by the physical capacity of the runway system. The current levels are 73 operations per hour at peak and 68

operations per hour sustained.* There are also 5 and 10 minute quotas to keep demand evenly spaced throughout the hour. The system is in effect all the time.

Peak demand occurs midday (see Figure 2). It has decreased from its 1973 high, but still approaches maximum capacity. International departures westbound are the major component of this peak.

Figure 2
Percentage of Arrival, Departure, and Total Air Transport Movements Handled in Each Hour of an Average Busy Day at Heathrow



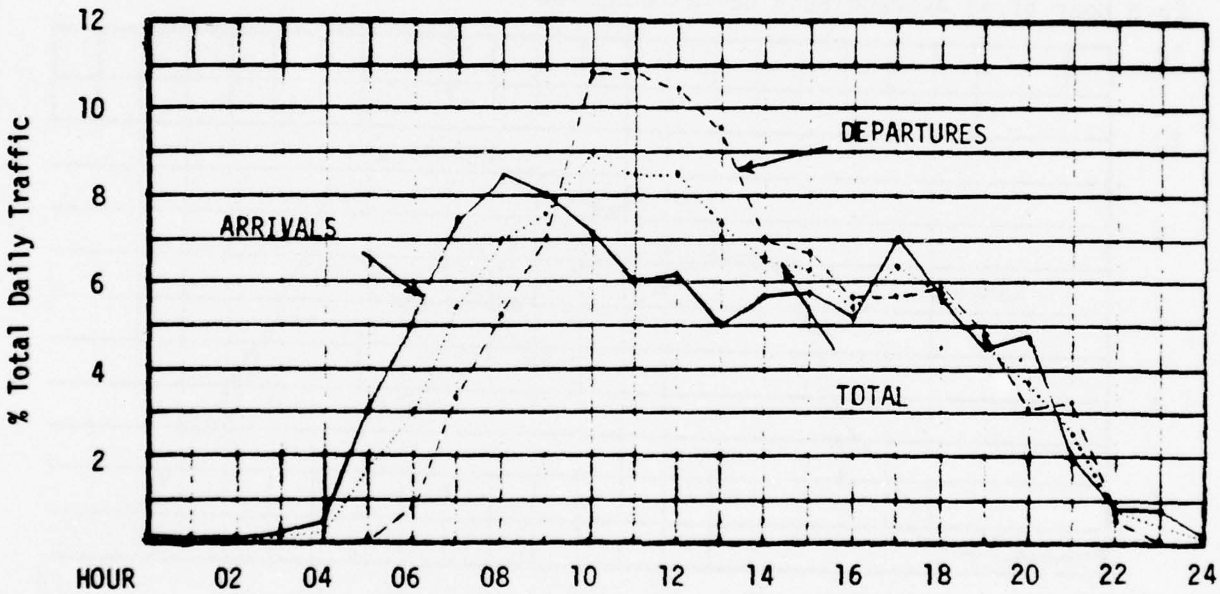
Slots are assigned twice a year by a scheduling committee composed of airline representatives. The allocations are based on historical patterns and bids for new slots. There has been a tendency for airlines to ask for more slots than are actually available but to then use fewer slots than assigned, creating some excess capacity. Neither the BAA nor the CAA participates in the slot allocation process.[8]

*Heathrow has a capacity of 90 operations per hour based on U.S. standards. The difference is almost entirely due to the smaller separation distance between aircraft used in the United States.

Landing Fees at Heathrow

Both the BAA and the CAA charge a fee at Heathrow. The CAA's navigation charge is based on weight and is currently about $1.15 per metric ton or $1.05 per short ton. Domestic flights within the U.K. pay about 15% less.[9] This fee is for landings only and is billed and collected by the BAA for the CAA.

Figure 3
Percentage of Arrival, Departure, and Total Passenger Traffic Handled in Each Hour of an Average Busy Day at Heathrow



SOURCE: BAA Aviation Statistical Service. Patterns of Traffic at the British Airports Authority Airports - 1974 (March, 1975).

Prior to 1971, the BAA also used a traditional weight-based landing fee formula. At that time, faced with ever-increasing congestion and peaking in the terminals (see Figure 3), access roads, etc., the BAA decided that "something ought to be done" about the congestion problem. Although the landing fee was still primarily considered as a way of raising revenues, the BAA recognized its potential as a tool for spreading demand and allocating costs more equitably.

> To sum up our policy on landing charges, we felt it was wrong to continue with our old system in current conditions and in the conditions we will be facing over the next few years of increasing pressure of traffic demand at peak times. It would be wrong to charge exactly the same fee for an aircraft landing at off-peak times, when costs occasioned by the landing are very low, as at peak times, when the costs occasioned by landing and take-off are very high. Similarly, it would be wrong to charge an aircraft with very few passengers on board the same fee as a fully loaded aircraft. [10]

Three points about the BAA's decision must be emphasized. First, it was philosophical and not based on financial needs. Second, although the system was originally planned as a means of controlling air traffic congestion, landside considerations have grown in relative importance over the past few years. Third, although the theoretical basis for peak charges was understood, no expensive analytical studies, models or forecasts were made to support the BAA's decision. To this date, the landing fee system and its modifications have been approached pragmatically in a spirit of "let's make a change and see if it moves us in the right direction."[11]

In 1972, the landing fee was modified to include a weight element, a distance element and a per passenger element. In addition, a surcharge was imposed that varies with season and time of the day. The surcharge applies to take-offs as well as landings (the landing fee only applies to landings) and is based on the actual not the scheduled time of operation. Because the BAA already monitors traffic movements for gate assignment purposes, there is little additional administrative cost imposed for monitoring actual operation times.

The distance element is based on the ultimate origin or destination of the flight, not its prior or next stop. Three zones were defined — domestic, European and international — that roughly defined short, medium and long range.*

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*There are some obvious distortions in this system — e.g. London-Paris is a short flight but would still be classified as European. However, this classification system was chosen for its ease of implementation.

The ratio of charges is one to two to four for domestic to European to international. This is based on a value-of-service pricing concept. The longer the flight, the greater the revenues and the lower the sensitivity to higher landing charges.

The per passenger charge also varies with distance and is based on the actual number of people deplaned (transit passengers are not charged). The airlines are required to report this data anyway, so there is no additional burden imposed. Table 1 lists the weight, distance and passenger charges effective November 1, 1975.[12] This basic charge is in effect 24 hours per day throughout the year. Table 2 lists some representative landing fees applying the current rate structure and lists the charges at Paris and Frankfurt as comparisons.[13]

Table 1

British Airports Authority Landing Fees for Aircraft

Over 16 Metric Tons (November 1, 1975)

Ultimate Origin or Destination	Per Metric Ton (Dollars) (First 50 tons)	Per Metric Ton (Dollars) (Thereafter)	Per Terminal Passenger (Dollars)
Domestic	.70	.90	.70
European	1.40	1.80	1.20
Intercontinental	2.80	3.60	2.40

Peak Movement Surcharge

Whereas the distance and weight related charges are based on a value-of-service concept, the peak movement surcharge is based on a cost-of-service concept. It is an attempt to pass on congestion costs to those creating the congestion.

Table 2

Typical Landing Fees at Heathrow and Other European Airports, Excluding Surcharge.
(November 1, 1975)
(Dollars)

Flight Classification	Aircraft	BAA		CAA	Total Charge	Paris 1/1/75 (includes noise tax)	Frankfurt 1/11/74
		Weight Charge	Passenger Charge	Navigation Charge			
Domestic	Trident 3B 69 tons 90 pass.	49.40	63.00	69.00	181.40	332.22	307.14
European	Trident 3B 69 tons 90 pass.	104.20	108.00	80.04	292.24	593.44	577.94
Intercontinental	B707/300 153 tons 110 pass.	510.80	264.00	177.48	952.28	1,085.88	1,034.56
Intercontinental	B747 325 tons 185 pass.	1130.00	444.00	377.00	1,951.00	2,235.38	2,023.42

The surcharge was first introduced for the 1972 summer season. It was intentionally small at first to "get the airlines accustomed to the idea".[14] The intent was to review the charge periodically and to modify it as revenue needs and congestion patterns changed.

The initial charge was £ 20 (about $50 at the time)* and applied to all operations: take-offs as well as landings. The charge applied for 4 hours each day, between 8:00 and 11:59 a.m. In May and June, 1972, it only applied Monday through Friday. From July through early October, it was in effect seven days a week. In total, the charge applied on 150 days for a total of 600 hours.[15]

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* Data in this section will be given in pounds for consistency because the exchange rate has varied over this time period.

Table 3

Heathrow Peak Operation Surcharges for 1974

Month	Time of Day	Charge
April, 1974 (7 days a week)	8:00-8:59 am 9:00-10:59 am 11:00-11:59 am	£ 20 £ 50 £ 20
May-October, 1974 (7 days a week)	8:00-8:59 am 9:00-11:59 am 12:00-12:59 pm	£ 20 £ 50 £ 20
Nov. 1974-March, 1975 (Monday-Friday only)	9:00-10:59 am	£ 20

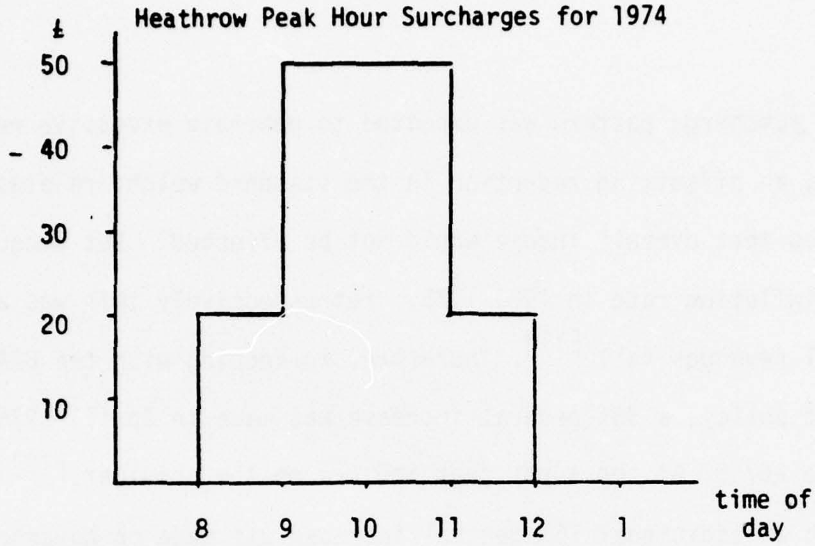
Although the original intent had been to adjust the charge for the summer of 1973, a price freeze was in effect. Therefore, both the level of the charge and its period of application were the same in 1973 as in 1972.

In the fall of 1973, the BAA reviewed both the effects of the surcharge to date and its latest traffic growth forecasts. As a result, the surcharge schedule for 1974 was modified to apply on more days and to vary during the daily surcharge period. The pattern is summarized in Table 3 and Figure 4.[16]

The £50 "super peak" surcharge was in effect on 214 days and for 612 hours, while the £20 "shoulder" surcharge applied on 321 days for 642 hours.

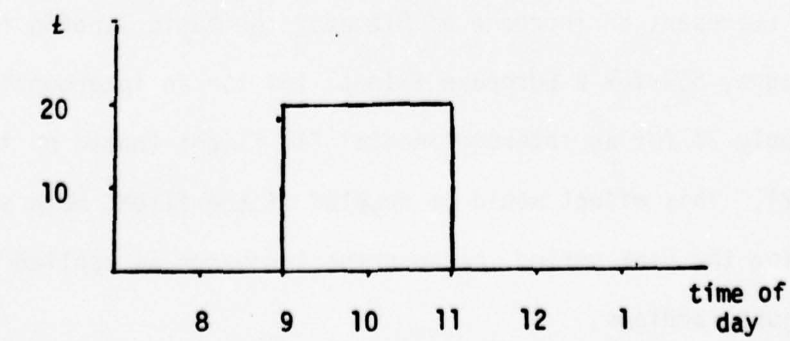
Figure 4

Heathrow Peak Hour Surcharges for 1974



a. April, 1974

b. May - October, 1974



c. November, 1974 - March, 1975 (Monday - Friday only)

This surcharge pattern was expected to generate excessive revenues. Therefore, an offsetting reduction in the standard weight related charge was made so that overall income would not be affected. But because of the high inflation rate in 1974-1975, retrospectively this was a mistake as overall revenues fell.[17] Therefore, in keeping with the BAA's pragmatic adjustment policy, a 35% general increase was made in April, 1975, raising the charges to £67.50 at the super peak and £27 on the shoulder.[18] Revenues still lagged and an additional 15% general increase was made on November 1, 1975, and the full summer peak and shoulder pattern was extended to April. Table 4 shows the current surcharge structure.[19]

Table 4

Heathrow Peak Operation Surcharges
Effective November 1, 1975

Month	Time of Day	Charge
April - October	8:00-8:59 am	£ 30
	9:00-11:59 am	£ 80
	12:00-12:59 pm	£ 30
November - March (Monday - Friday only)	9:00-10:59 am	£ 30

Note that the £ 80 super peak surcharge, at a conversion rate of $2 per pound would represent an increase of 87% over the basic landing fee for a domestic flight, 55% for a European flight, 15% for an intercontinental 707 flight and only 7% for an intercontinental 747 flight (based on the data from Table 2). This effect would be doubled if the flight both arrives and departs during the peak period, because the surcharge is applied to all operations, not just landings.

Impact on Traffic

Although the surcharge did represent a significant additional charge to general aviation traffic, this segment was already severely rationed during busy hours by the NATS slot system. The relatively low surcharge in effect during 1972 and 1973 was not expected to have much impact on airline traffic levels. The results were encouraging however. During 1972, total aircraft traffic increased 0.8% over the 150 days the surcharge was in effect. But traffic during the four hour surcharge period decreased 1.7%. During 1973, overall traffic for the same 150 day period rose 6%, but traffic during the surcharge hours rose only 2.4%. The percentage of the total traffic that moved during the four hour surcharge period fell from 28.4% in 1971 to 26.7% in 1973. This data is summarized in Table 5.[20]

Table 5

Heathrow Aircraft Movements on 150 Summer Days
Before and After Peak Surcharge Introduced in 1972

	Total Movements	Charge from Prior Year	Movements During Peak	Charge from Prior Year	% Traffic Moving During Peak
1971	126,411	-	35,928	-	28.4%
1972	127,446	+0.8%	35,301	-1.7%	27.7%
1973	135,264	+6.1%	36,152	+ 2.5%	26.7%

With the higher surcharge instituted in 1974 and its longer period of application, more substantial shifts were expected. However, quite the reverse took place. While overall traffic fell 3.9%, traffic during the

super peak period increased 1.1% overall. Traffic during the shoulder periods fell 6.6%.¯ The percentage of traffic moving during the super peak rose from 19.6% in 1973 to 20.6% in 1974, and the percentage moving during the combined super peak and shoulder period rose from 33.8% to 34.4%. This data is summarized in Table 6.[21]

Table 6

Heathrow Aircraft Movements on 214 Summer Days
Before and After Surcharge Modified in 1974

	Total Movements	Movements During Peak	% Traffic Moving During Peak	Movements During Shoulder	% Traffic Moving During Shoulder	% Traffic Moving During Peak and Shoulder
1973	188,809	36,928	19.6%	26,865	14.2%	33.8%
1974	181,501	37,341	20.6%	25,098	13.8%	34.4%
Change from Prior Year	-3.9%	+1.1%	+5.1%	-6.6%	-10.3%	+1.8%

Table 7 shows how the traffic mix changed from 1973 to 1974.[22]

Table 7
Per Cent Change over Previous Year for Types of Traffic
Operating During Peak Surcharge Periods

	During Super Peak	During Shoulder	Total
Non-Air Transport	-13.9%	-25.0%	-16.1%
Cargo	- 5.6%	-	- 3.5%
European	- 0.3%	+ 1.6%	- 1.6%
Intercontinental	+ 2.3%	-22.4%	- 5.9%
Domestic	+ 8.6%	- 3.7%	+ 1.8%

As might be expected, non-transport and cargo operations were most affected. European (medium haul) and intercontinental (long haul) were much less affected because the surcharge is a small percentage of their total cost. However, domestic traffic, which should be more sensitive to increased costs, actually showed the biggest increase in super peak operations!

The BAA hypothesizes that these unexpected results were brought on by the fuel crisis. As airlines cut out marginal flights, overall traffic levels fell. Remaining flights were consolidated at times of peak demand to maximize load factors. The peak surcharge was too little to offset these other factors.[23] It is also difficult to separate out several other effects taking place during this time period: an increase in the number of ATC allocations available per hour; normal schedule shifts for equipment or other reasons; continued introduction of wide bodied aircraft; and general economic decline.

Latest data available (November, 1974 through February, 1975) indicates that, as the fuel crisis slackened, the effects of the Winter surcharge were more in line with normal expectations. Although overall traffic on the 86 days during which the Winter surcharge applied increased 2.8%, traffic during the peak only increased 0.5%. The percentage of peak traffic to total traffic fell from 15.6% to 15.3%. Most of the change was probably due to the diversion of non-transport traffic.[24]

<u>Plans for the Future</u>

Over the past five years, the major concern of the BAA has shifted from runway and taxiway congestion to terminal and access congestion. As a result, the pricing structure is being modified to reflect congestion costs due to both aircraft and passenger peaking. As of December, 1975, a new system is being proposed that not only assesses an aircraft movement surcharge as in the past but also imposes a per passenger surcharge during the peak. There will no

longer be a passenger charge in the basic landing fee structure. In fact, there will not be any per passenger charge during off-peak periods. During the shoulder, there will be a per passenger charge of $1 for domestic operations and $2 for all international operations -- European or other. During the super peak these charges will be $2 and $4 per passenger respectively.

There will also be a weight-distance basic landing charge in effect at all times. Unlike the current domestic-European-international break down, the new system will be more closely related to actual distances. There will be five zones -- domestic and international to 500 miles, to 2,000 miles, to 4,000 miles and to more than 4,000 miles. The peak hour surcharge per operation will also be increased. As a result of this new structure, a long-haul international flight will pay a 30% premium for an operation during the shoulder and a 60% premium for an operation during the super peak. A short-haul international flight will pay twice the basic fee during the shoulder and four times the basic fee during the peak.[25]

Conclusion

The BAA has adopted a rational pricing scheme and a rational approach to its implementation. The operational surcharge system, coupled with a weight-distance basic landing fee structure, is a good compromise between economic marginal pricing concepts and financial revenue requirements. Although there is some data indicating that the surcharge is shifting demand slightly, it has not resulted in any significant shifts because the surcharge component is still small as compared to the basic landing fee. However, this is in keeping with the BAA's basic pragmatic approach of starting low to get users accustomed to the concept and then modifying the pricing scheme gradually as conditions justify or require it. The BAA's experience during the next few years should be closely followed because the surcharge is becoming a significant part of

the basic fee and airlines can be expected to react more strongly than in the past.

Some caution should be used in extrapolating the BAA's experience to the United States situation. First, the BAA's profit-oriented charter is alien to what seems to be the prevailing U.S. philosophy that airports, as a public service, should break even at best. Second, basic landing fees in Europe are much higher than in the U.S. The imposition of the large surcharges that may be needed to make the airlines shift flights would be a great shock to U.S. carriers accustomed to low fees and strong political protests can be expected. Third, the BAA's surcharge and landing fee systems work in conjunction with the NATS operational quota system. Some care must be taken to separate the effects of one from the other. Finally, the BAA's emphasis has been shifting from air traffic congestion problems to terminal congestion concerns. The surcharge structure that deals best with one problem may not be best for the other.

All things considered, the BAA's approach of gradual introduction and change may be useful in the U.S. if a surcharge system is implemented. It might both ease the shock of increased fees to the airlines and/or minimize system disruption if the initial price structure is incorrect or has unwanted effects.

The New York Case Study

The Port Authority of New York and New Jersey (formerly the Port of New York Authority - PONYA) was established by a Compact between the two states in 1921 as a financially self-supporting agency to develop and operate terminal, transportation and other facilities of commerce within the two-state Port of New York District.[26]

The Authority operates the major commercial airports in the New York City region - John F. Kennedy International, La Guardia and Newark International.*[27] It also operates Teterboro Airport in New Jersey as a general aviation facility.**[28] As of December 31, 1974, the Port Authority had invested $1,262,723,000 in its airports.[29]

The Port Authority has also assisted the New York Metropolitan Transportation Authority in developing Stewart Air Force Base, Newburgh, New York, and Republic Airport on Long Island as major general aviation facilities.[30]

The Congestion Problem

Air traffic congestion at New York City's three major airports increased through the early 1960's until, during the controller's slowdown of July, 1968,

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* In 1947, the legislatures of the two states specifically authorized the Port Authority to operate air terminals. It entered into long-term leases with the City of New York that same year under which the Port Authority took over the development and operation of La Guardia Airport (originally built from 1937 to 1939) and New York International Airport (opened in 1948 and re-dedicated as John F. Kennedy International Airport in 1963). In 1948, the Port Authority entered into a similar agreement with the City of Newark to operate and develop Newark Airport (originally built in 1928) and the adjacent Port Newark facilities.

** In 1949, Teterboro was purchased from a private owner. Starting in 1970, the operation of Teterboro was assumed by Pan American World Airways under a 30 year agreement which precludes the use of Teterboro for any scheduled flights other than helicopter service.

17% of all operations in the region (excluding Teterboro) were delayed by more than 30 minutes (over 29% at Kennedy).[31] During that month, General Aviation (GA) operations constituted 25% of the region's movements overall and 30% during peak hours (see Table 8 for distribution by airport).[32]

Table 8

General Aviation Percentage of

Total Movements - July, 1968

	All Hours	Peak
Region	25.0	30.0
Kennedy	16.6	20.7
La Guardia	32.1	34.4
Newark	29.6	36.2

To make more capacity available for air carrier operations, on August 1, 1968, the Port Authority imposed a $25 fee for all landings and take-offs during peak hours by aircraft with less than 25 seats. This replaced the normal $5 landing fee and was done with the

> professed purpose of relieving congestion and achieving maximum efficient operation at the three major airports and with the professed intention of influencing General Aviation operators to transfer their operations where possible away from the runways and traffic control patterns at the three major airports during peak periods....[33]

This new minimum fee applied from 8:00 a.m. to 10:00 a.m. Monday through Friday and from 3:00 p.m. to 8:00 p.m. every day. Air taxi operators

providing scheduled connecting service at Kennedy and Newark could obtain permits exempting them from the peak hour rates whenever they used runways not in use by the scheduled airlines. This exemption did not apply at La Guardia because there was little chance of non-interfering runway use.[34]

The impact of this surcharge was immediate. In August and September, GA activity fell 19% overall and over 30% during the peak period. Historically, GA traffic in these months stayed at the July level, so the decline was directly related to the surcharge. Without it, the traffic levels might have even increased as the controller slow down was phased out. This information is summarized in Table 9.[35]

Table 9

General Aviation Percentage Decline
From July 1968

	Decline in August		Decline in September (Based on 31 Day Month)	
	All Hours	Peak Hours	All Hours	Peak Hours
Region	-19	-31	-19	-32
Kennedy	-7	-18	-11	-27
La Guardia	-28	-41	-25	-37
Newark	-17	-30	-17	-30

Table 10 gives the percentage of aircraft delayed by 30 minutes or more for the same time period.[36] As might be expected, the improvement was substantial.

Table 10

Percentage of Aircraft Delayed by 30 Minutes or More - July, August, September, 1968

	July	August	September
Region	17.0	14.1	7.6
Kennedy	29.4	27.1	12.2
La Guardia	12.0	5.2	4.6
Newark	2.8	2.8	3.4

Figure 5 shows the overall level of GA operations at the three airports by month for 1967 and 1968.[37] In 1967, monthly operations averaged from 22,000 to 25,000 for the May to October period. 1968 levels exceeded 1967 through the Winter and Spring. They flattened out in July with the controllers' slowdown, then fell 13% below the 1967 level for August and 22% below the 1967 level for September. In contrast, airline operations increased over 8% for each month.[38]

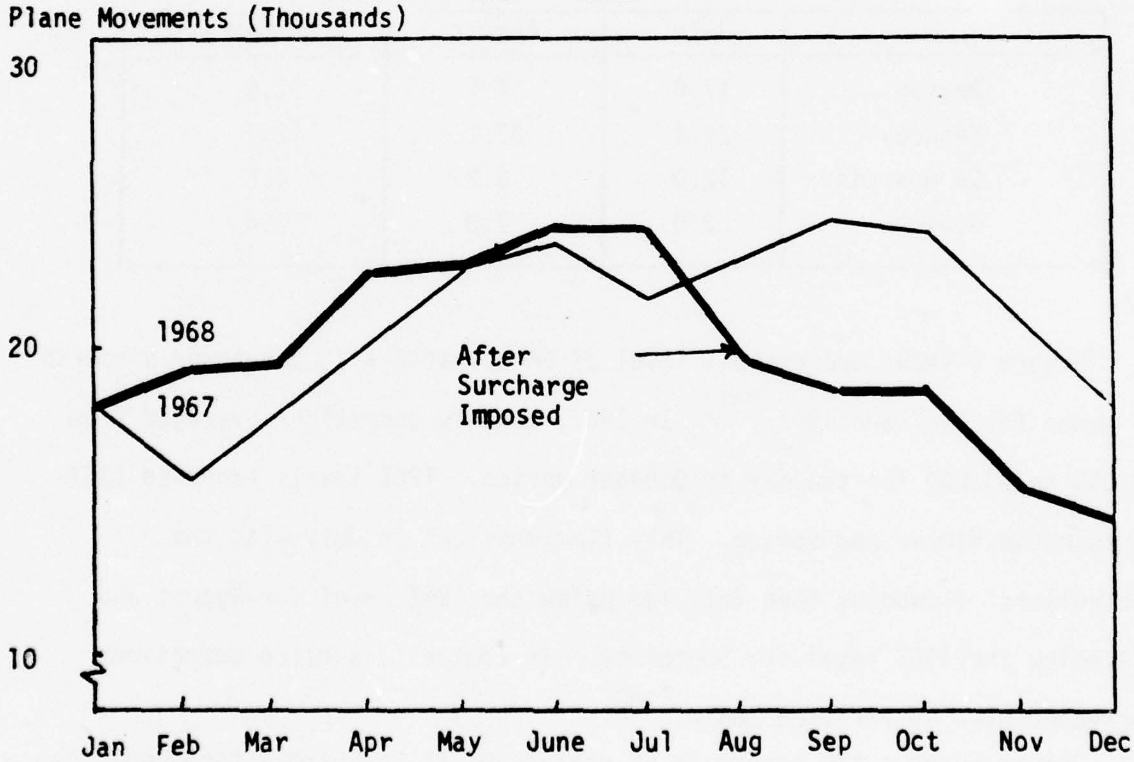
Figure 6 shows the change in GA operations at La Guardia throughout the day for an average day in July (before the surcharge) and in August and September, 1968 (after the surcharge).[39] Again, the reduced levels of operation are significant. Prior to the surcharge there was a morning peak of 18-20 operations per hour from about 9 a.m. to noon and an evening peak of 24-25 operations per hour from 3 p.m. to 7 p.m. In August, the pattern was totally altered. A peak of about 15 operations per hour occurred between 10 a.m. and 1 p.m. Operation

levels during what had been the afternoon peak period were less than 60% of the July levels.*

Figure 5

General Aviation Movements at
the New York Region's Three Major Airports

1967 - 1968



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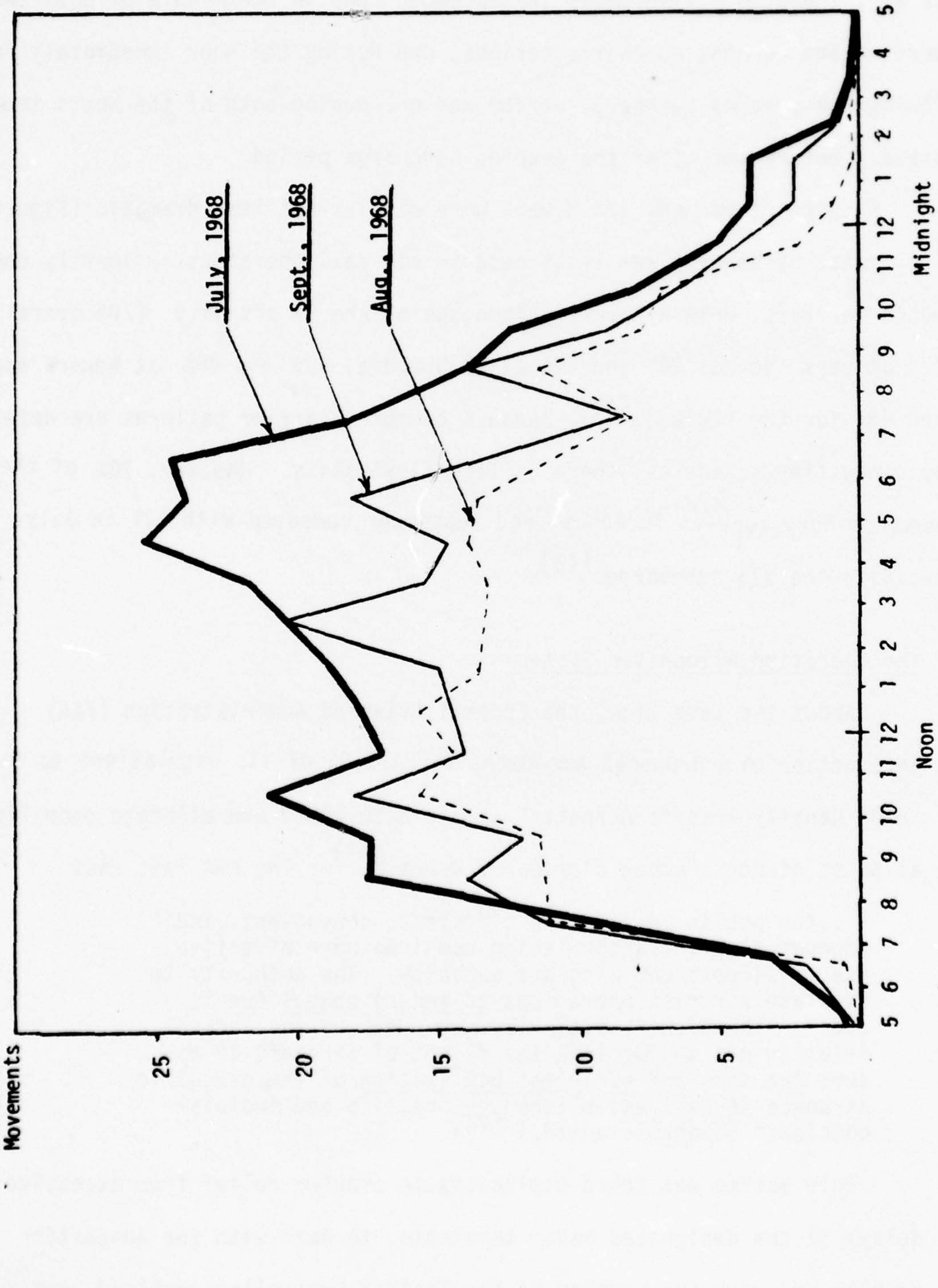
* Data obtained from Figure 6.

Figure 6
La Guardia Airport
General Aviation Movements
Average Day Before and
After Surcharge (1 Aug., 1968)



In September, traffic levels rose over August, but there were still 5 to 10 fewer operations per hour during the surcharge period than in July. In all, there were five peaks in September: one in the middle of both the morning and evening surcharge periods, one during the hour immediately following the morning surcharge period and one during both of the hours immediately before and after the evening surcharge period.

Results at Kennedy and Newark were similar but less dramatic (Figure 7).[40] The impact at Kennedy was least because air taxi operators, primarily commuter carriers, were a larger percentage of the GA activity (70% overall and 72% at peak versus 26% and 29% at La Guardia, 48% and 48% at Newark and 45% and 46% for the region).[41] Because commuter carrier patterns are determined by connecting schedules, there is less flexibility. However, 78% of the commuters used non-duty runways in August and September compared with 52% in July, thus avoiding the $25 surcharge.[42]

The Operation Allocation System

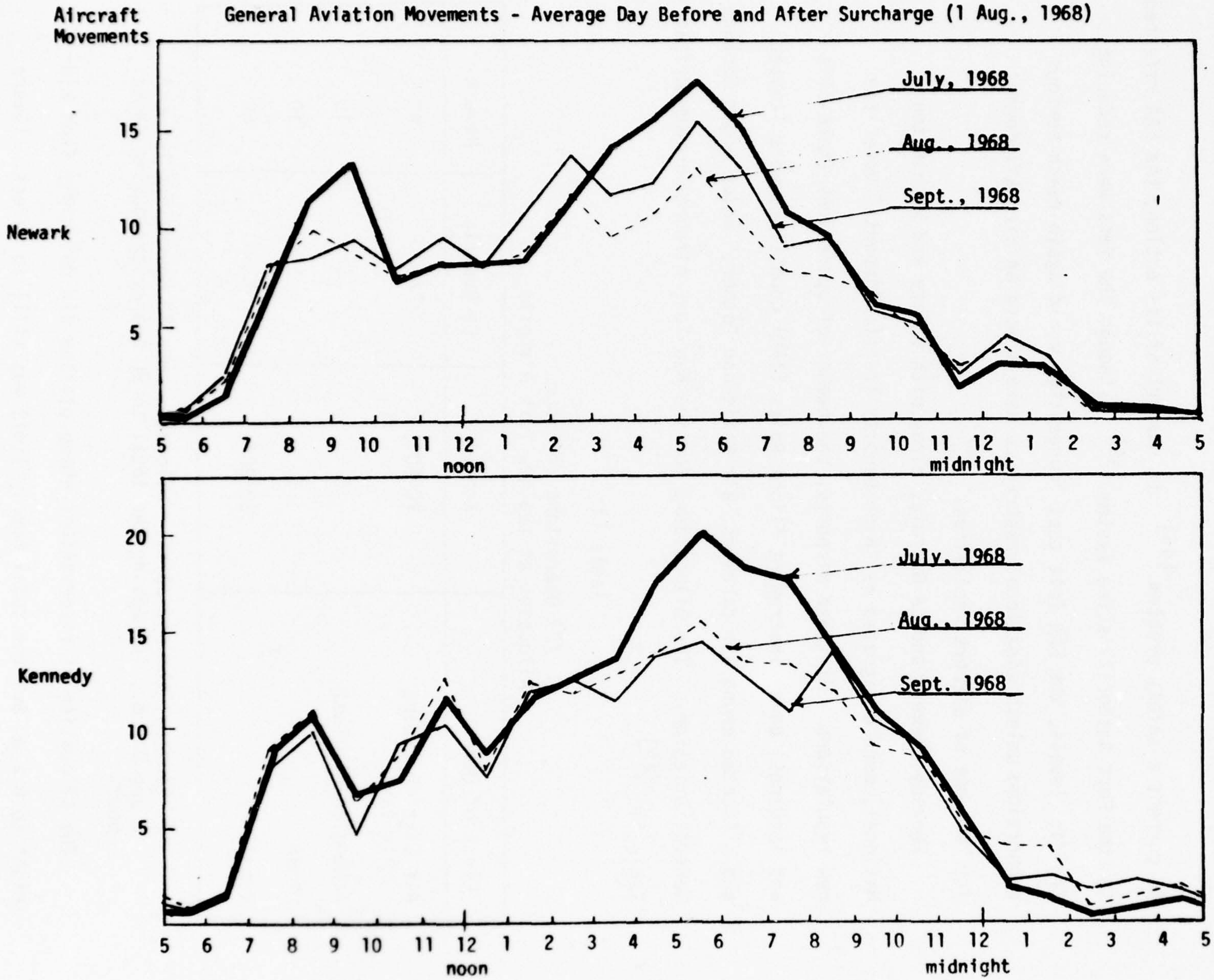
About the same time, the Federal Aviation Administration (FAA) gave notice of a proposed amendment to Part 93 of its regulations to designate "High Density Traffic Airports" and to both limit and allocate operations at those airports among classes of users.[43] The FAA felt that

> "...the public interest in efficient, convenient, and economical air transportation requires more effective use of airport and airspace capacity. The authority to regulate aircraft operations <u>to reduce congestion</u> is clear. The plenary authority <u>conferred</u> by the Federal Aviation Act to regulate the flight of aircraft to assure the safe and <u>efficient utilization</u> of the navigable airspace is well established by practice and judicial opinion." (Emphasis added.) [44]

This action was taken explicitly to provide relief from excessive delays at the designated major terminals, to deal with the congestion problem and with the problem of Air Traffic Controller workload and not

Figure 7

General Aviation Movements - Average Day Before and After Surcharge (1 Aug., 1968)



to correct a safety problem.[45] In support of its action, the FAA referred to the Port Authority's fee system.[46] Although the fees were reducing traffic levels, the FAA felt that "congestion would again reach serious proportions unless additional restraints were placed on aircraft demand for the use of airport facilities." [47]

Kennedy, Newark and La Guardia, along with O'Hare and Washington National, were designated as "High Density Traffic Airports" under the new regulations. At these airports, the number of operations (take-offs and landings) under Instrument Flight Rules (IFR) conditions were limited and allocated among air carriers, air taxis and "other," which would include General Aviation. The allocations for the New York Airports are summarized in Table 11. [48]

Table 11

IFR Operations per Hour
Allocated at the New York Airports

Class of User	Kennedy	La Guardia	Newark
Air Carrier Except Air Taxi	70(80*)	48	40
Scheduled Air Taxi	5	6	10
Other	5	6	10
Total	80(90*)	60	60

*At Kennedy, the air carrier allocation was 80 operations between 5 and 8 p.m., increasing the total to 90 operations during those hours.

The allocation of reservations among classes did not apply from midnight to 6 a.m. but the total hourly limit was still in effect. (Extra

sections of air carrier flights, other than air taxi, were exempt at all times.) Any reservation allocated but not used by an air carrier was available for scheduled air taxi operations. Any reservation allocated but not used by an air carrier or scheduled air taxi was available for other operations. [49] Under all conditions, IFR and VFR (Visual Flight Rules which apply when minimum visibility requirements are met), all operations to or from these airports had to have an air traffic control (ATC) arrival or departure reservation, except from midnight to 6 a.m. [50] ATC could permit IFR operations above the limits if the operator obtained an arrival or departure reservation in advance. ATC could grant this additional reservation if the aircraft could be accomodated without significant additional delays to the operations already allocated. [51]

The Impact on Traffic

The allocation system went into effect on June 1, 1969. [52] To analyze its effects the Port Authority reviewed tower logs and compiled average June-July and August-September data for 1968 and 1969. June-July 1968 corresponds to the period before the surcharge; August-September 1968 corresponds to the period after the surcharge but before the quota system. Both surcharge and quotas were in effect during 1969. [53] Although there were some differences due to the 1968 controllers' slow down and the number of days when IFR conditions prevailed, the results are still significant. GA activity dropped 43% overall between June-July 1968 and 1969 and 49% during the 3 p.m. to 8 p.m. peak period. Between August-September 1968 and 1969, GA dropped 31% both overall and at the peak. Because the surcharge was already in effect during August-September 1968, traffic during those months had already fallen 20-30% from June-July, 1968. Therefore, the total traffic during August-September 1969 was 44 per cent less than in July, 1968. This information is summarized in Tables 12 and 13. [54]

TABLE 12

AIRCRAFT MOVEMENT SUMMARY
JUNE-JULY

	1968	1969	Percent Change
JFK*			
Avg. Day - Total	1,275	1,190	- 7
Air Carrier - Total	1,074	1,060	- 1
3-8 PM	66	65	- 2
5-8 PM (Extra Alloc.)	69	67	- 3
General Aviation - Total	201	130	-35
3-8 PM	16	9	-44
5-8 PM	17	9	-47
La Guardia*			
Avg. Day - Total	963	878	- 9
Air Carrier - Total	646	732	+13
3-8 PM	44	48	+ 9
General Aviation - Total	317	146	-54
3-8 PM	21	9	-57
Newark*			
Avg. Day - Total	701	663	- 5
Air Carrier - Total	497	531	+ 7
3-8 PM	32	34	+ 6
General Aviation - Total	204	132	-35
3-8 PM	16	9	-44
Region			
Avg. Day - Total	2,939	2,731	- 7
Air Carrier - Total	2,217	2,323	+ 5
3-8 PM	142	147	+ 4
General Aviation - Total	722	408	-43
3-8 PM	53	27	-49

*FAA ALLOCATIONS

	JFK 1/	La Guardia	Newark
Air Carrier	70	48	40
General Aviation	10	12	20

1/ Air carrier allocation increases to 80 in the 5 PM-8 PM period

Note: The figures for 3 PM-8 PM and 5 PM-8 PM are average hourly movement rates for those periods.

TABLE 13

AIRCRAFT MOVEMENT SUMMARY
AUGUST-SEPTEMBER

	1968	1969	Percent Change
JFK*			
Avg. Day - Total	1,264	1,184	- 6
Air Carrier - Total	1,070	1,046	- 2
3-8 PM	65	67	+ 3
5-8 PM (Extra Alloc.)	69	69	-
General Aviation - Total	194	138	-29
3-8 PM	14	9	-36
5-8 PM	14	9	-36
La Guardia*			
Avg. Day - Total	865	843	- 3
Air Carrier - Total	641	701	+ 9
3-8 PM	46	48	+ 4
General Aviation - Total	224	142	-36
3-8 PM	14	9	-36
Newark*			
Avg. Day - Total	667	639	- 4
Air Carrier - Total	495	514	+ 4
3-8 PM	32	33	+ 3
General Aviation - Total	172	125	-27
3-8 PM	11	9	-18
Region			
Avg. Day - Total	2,796	2,666	- 5
Air Carrier - Total	2,206	2,261	+ 2
3-8 PM	143	148	+ 3
General Aviation - Total	590	405	-31
3-8 PM	39	27	-31

*FAA ALLOCATIONS

	JFK 1/	La Guardia	Newark
Air Carrier	70	48	40
General Aviation	10	12	20

1/ Air carrier allocation increases to 80 in the 5 PM-8 PM period

Note: The figures for 3 PM-8 PM and 5 PM-8 PM are average hourly movement rates for those periods.

Although air carrier traffic was up at each airport, overall operations were down. In fact, both air carrier and GA were operating below their allocation levels even at peak (except for peak air carrier traffic at La Guardia).

Figures 8 and 9 show the GA movements at the three airports for an average day in July and August, 1969, superimposed on the 1968 figures shown earlier.[55] The combined effects of the surcharge and quota systems are quite substantial at La Guardia where the peak level of GA movements was reduced from 25 operations between 4 and 5 p.m. to 12 operations between 2 and 3 p.m. During the 3 p.m. to 8 p.m. period of peak congestion, the hourly levels of GA operations were about 30% of the July, 1968 levels. While somewhat less dramatic, peak operations at Kennedy and Newark also showed substantial reductions and a general spreading of demand throughout the day.[56]

At Kennedy, GA operations exceeded the GA quota between 1 and 2 p.m. and between 6 and 7 p.m. This was permitted because the air carriers were not using all their allocations during those hours.

Because demand at Newark and Kennedy did not approach the allocations available, the quota system was removed from Newark and restricted to the 3 to 8 p.m. peak at Kennedy in 1973.[57]

Figure 10 summarizes the overall trend in GA movements at the three major New York airports from 1967 through 1970.[58] In 1967, there were no controls. From August, 1968, to May, 1969, only the surcharge was in effect. From June 1969 on, both the surcharge and quota system were imposed. After each change the level of GA operations fell significantly.

FIGURE 8
LAGUARDIA AIRPORT
GENERAL AVIATION MOVEMENTS
Average Day Before and After
Surcharge (1 Aug., 1968) and Quota (1 June, 1969)

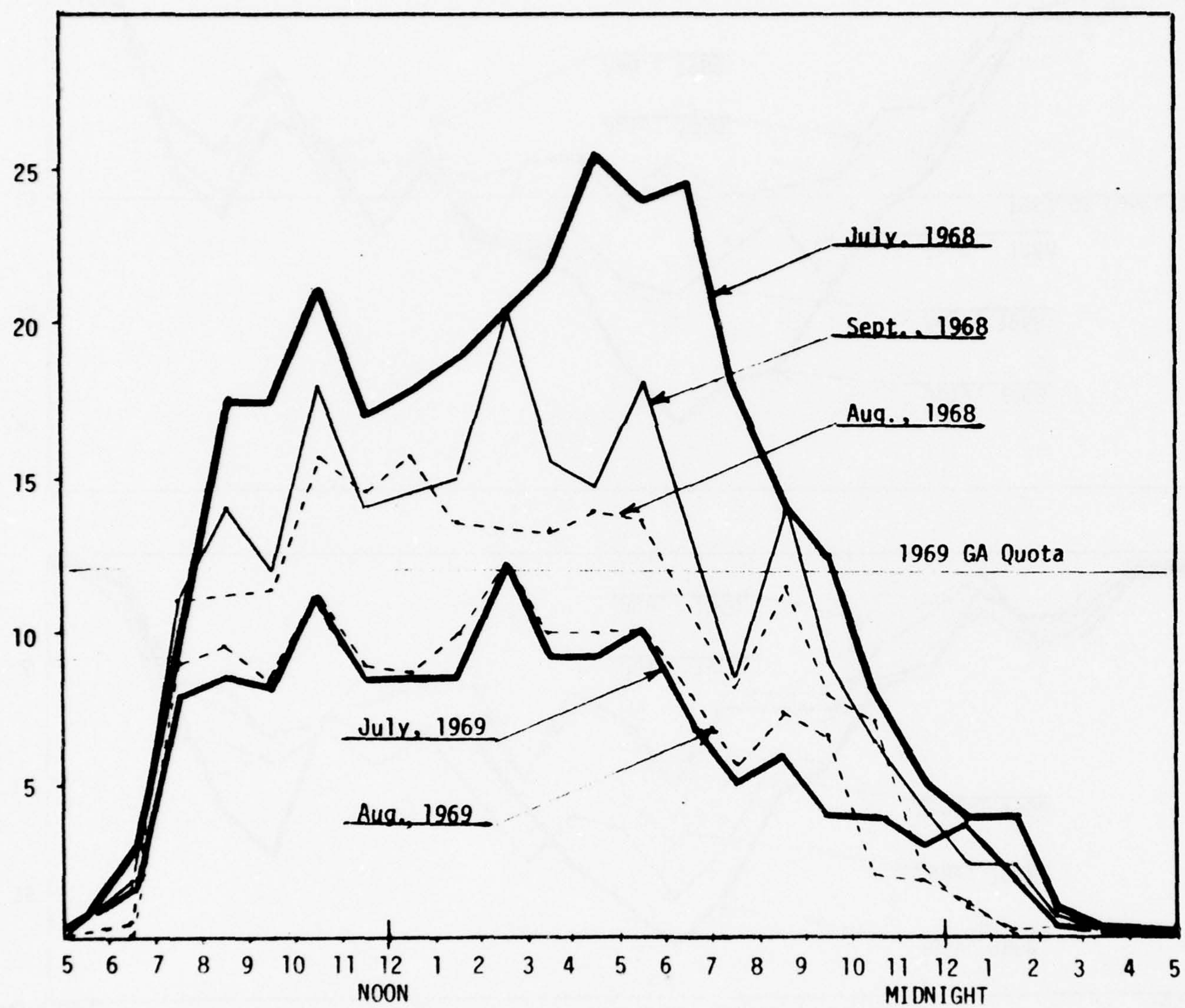


Figure 9
General Aviation Movements - Average Day Before and After
Surcharge (1 August, 1968) and Quotas (1 June, 1969)

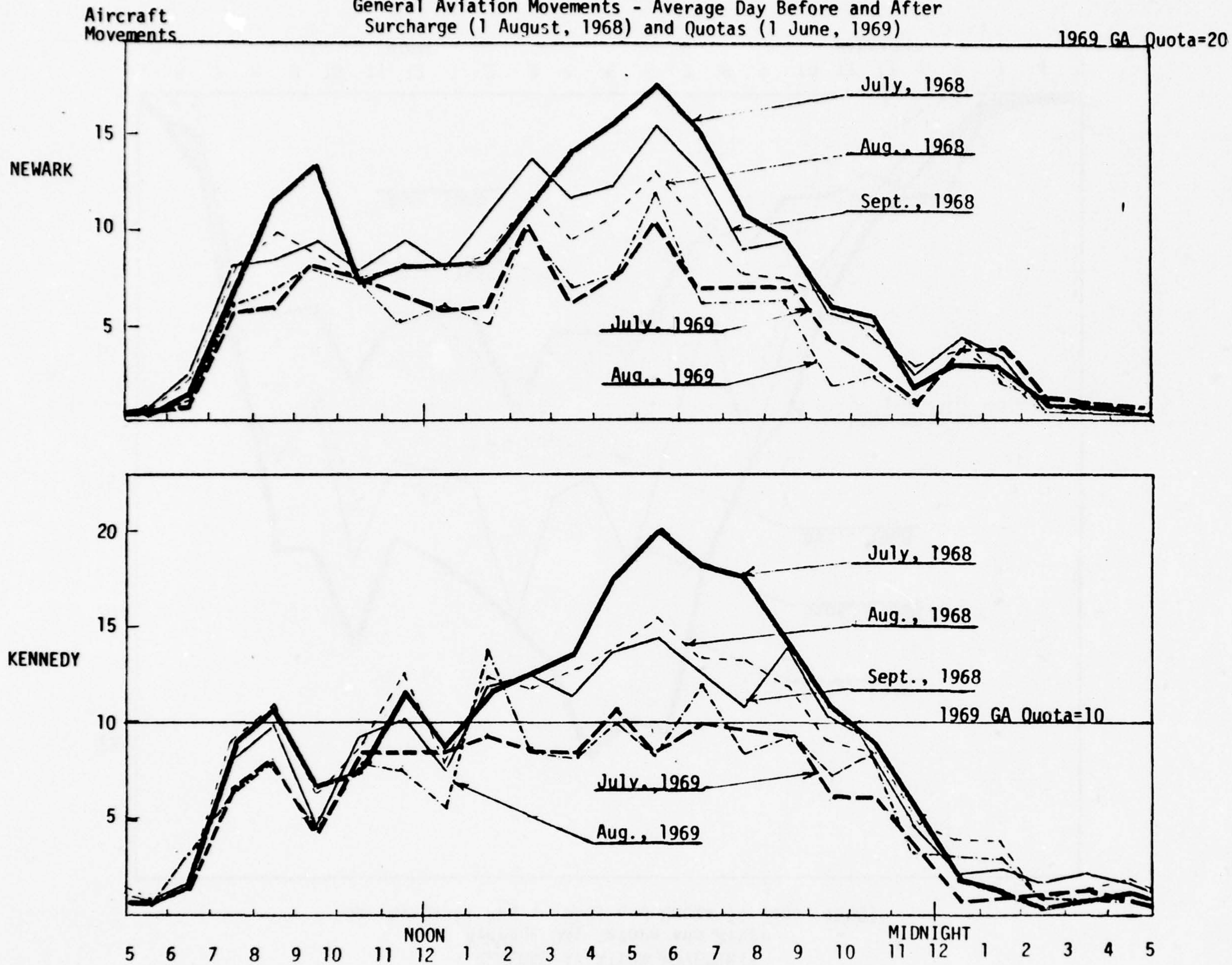
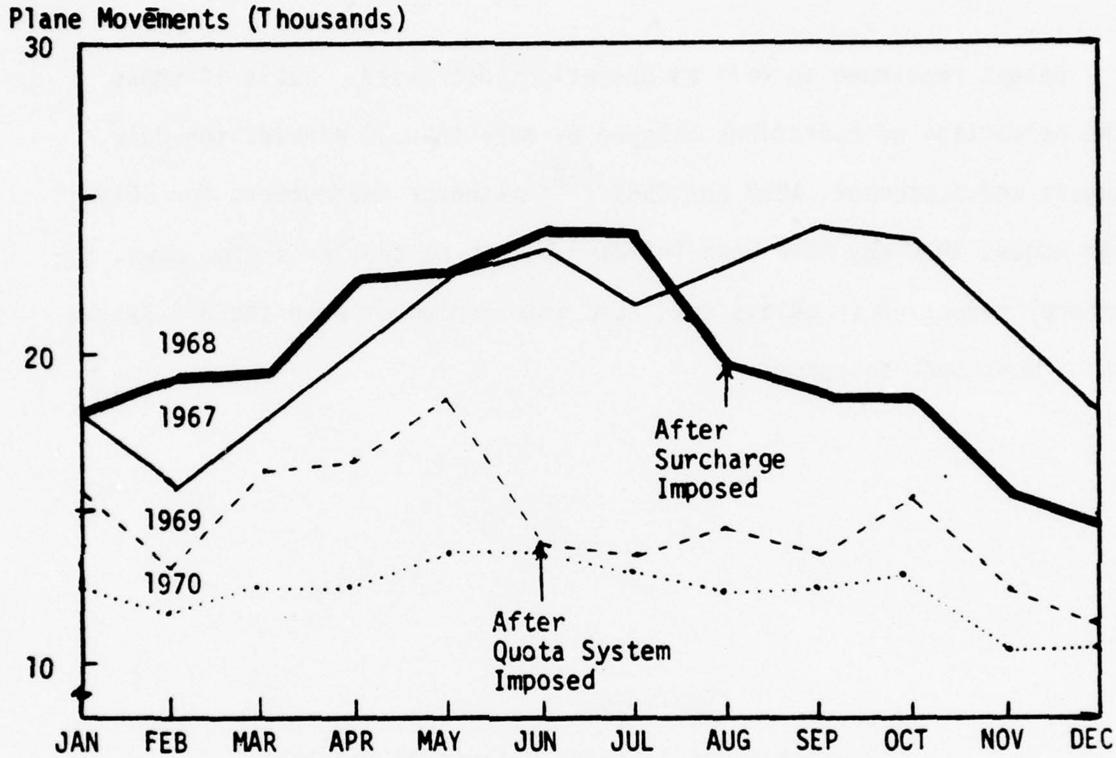


Figure 10

General Aviation Movement at
the New York Region's Three Major Airports
1967-1970



Delays continued to fall as operations decreased. Table 14 shows the percentage of operations delayed by more than 30 minutes for July, August and September, 1968 and 1969.[59] Although the numbers for July and August 1968 may have been inflated by the controller's slow down, the general reduction in delays continued into September when the ATC system was almost back to normal.

Table 14

Percentage of Aircraft Delayed 30 Minutes or More - July, August, September - 1968,1969

	July		August		September	
	1968	1969	1968	1969	1968	1969
Region	17.0	11.8	14.1	4.9	7.6	4.8
Kennedy	29.4	17.1	27.1	7.7	12.2	6.4
La Guardia	12.0	8.5	5.2	3.3	4.6	4.8
Newark	2.8	6.5	2.8	1.8	3.4	2.3

Table 15 shows the percentage change in overall operations and the percentage change in the number of aircraft delayed more than 30 minutes for the same time period.[60] While on the average traffic fell about 7%, delays fell about 50%.

Table 15

Percentage Change in Total Operations and Number of Operations Delayed by 30 Minutes or More Between July, August, and September 1968 and the Same Months in 1969.

	July		August		September	
	% Total	% Delayed	% Total	% Delayed	% Total	% Delayed
Region	-9.0	-67.0	-6.0	-67.0	-5.0	-39.0
Kennedy	-5.0	-45.0	-4.0	-73.0	-5.0	-51.0
La Guardia	-14.0	-38.0	-5.0	-39.0	-5.0	-2.0**
Newark	-12.0	+102.0*	-8.0	-41.0	-7.0	-35.0

* 6.5% (1,433) of total flights delayed as compared with 2.9% (708) flights in 1968.

** 2.3% (523) of total flights delayed as compared with 3.4% (808) flights in 1968.

Court Challenges

The Aircraft Owners and Pilots Association (AOPA), the primary national organization representing general aviation interest, challenged both the FAA's allocation system and the Port Authority's differential fee system in the courts as being discriminatory and contrary to the public policy of free access to the nation's airspace.

In formulating the quota system, the FAA conceded that

> This rule grants a greater priority to certificated air carriers, who provide common carrier service, in accordance with the policy of recognizing a national interest in maintaining a public mass air transportation system, offering service on equal terms to all who would travel...The concept of 'first come-first served' remains as the fundamental policy governing the use of air space so long as capacity is adequate to meet the demands of all users without immeasurable delay or inconvenience. When capacity limitations compel a choice, however, the public service offered by the common carrier must be preferred... [61]

This was challenged in Aircraft Owners & Pilots Association v. Volpe[62] as being discriminatory and contrary to the basic policy of the Federal Aviation Act that "There is recognized and declared to exist in behalf of any citizen of the United States a public right of freedom of transit through the navigable airspace of the United States."[63] Even though it agreed with AOPA that air carriers were given an advantage under bad weather conditions and that general aviation would experience considerable inconvenience and perhaps considerable readjustment, nevertheless the Court found that the regulation was proper after balancing the equities between general aviation and carrier and public interests. The Court held that "there was a rational basis for the rule adopted, that such a rule was within the regulatory authority delegated to the Administrator and that the Administrator had adopted the rule in a competent, deliberate and intelligent manner after having properly pursued the rule making procedures provided by the Administrative Procedures Act."[64]

The Court was influenced by the facts that the allocation system only applied during IFR conditions, or roughly 15% of the time, and that the original regulation was temporary and due to expire on December 31, 1969. Thus, "the relatively minor inconvenience, coupled with a critically serious congestion problem...,"[65] led the judge to uphold the regulation.

In Aircraft Owners and Pilots Assocation v. Port Authority of New York,[66] AOPA challenged the surcharge on three grounds. First, the imposition of a charge, with the specific intent of changing traffic patterns, was a direct interference with traffic regulation which is solely entrusted to the FAA by federal law and thus preempted from local control. Second, under its

enabling legislation and conditions imposed by the acceptance of federal airport funds, the Port Authority was prohibited from discriminating between types of traffic. Third, even if the Port Authority could make a distinction between mass transportation by air carrier and private or general aviation, the different treatment given air taxis as compared to other forms of general aviation was unjustly discriminatory.

The Preemption Issue

AOPA argued that the FAA's authority to regulate and control air traffic was so pervasive that there was no room for the Port Authority's surcharge with its clearly regulatory intent. Although there are several cases dealing with aviation noise control that would seem to support AOPA's position, on closer reading it is clear that the local noise control laws stricken down were in direct conflict with federal regulation.[67] The Court found that the fee schedule and its regulatory impact were not in conflict with the FAA's regulations but that they worked in the same direction.

> Nothing in the present fee schedule runs counter to the FAA regulation in the sense that it seeks to authorize conduct which the federal regulation prohibits or requires the cessation of a practice required by federal regulation. United in general purpose with the high density regulation, the revised fee schedule, if viewed as a regulation of air traffic, simply has the tendency further to restrict the traffic restricted by the federal regulation, but to do so in a direction of restriction and for an aim common to both sets of regulations. [68]

The Discrimination Issues

In addition to the freedom of airspace issue discussed in the Volpe case, AOPA claimed that discrimination by the Port Authority is prohibited by its acceptance of federal funds because "There shall be no exclusive right

for the use of any landing area or air navigation facility upon which Federal funds have been expended."[69] Likewise, under the terms of the Public Airport Development Act, before he can approve an airport project, the Administrator of the FAA

> "...shall receive assurances in writing satisfactory to him that -
>
> (1) the airport to which the project relates will be available for public use on fair and reasonable terms and without unjust discrimination..."[70]

In receiving federal funds, the Port Authority had specifically agreed that

> "...it will keep the airport open to all types, kinds and classes of aeronautical use without discrimination between such types, kinds and classes; Provided...[it] may establish such fair, equal and not unjustly discriminatory condition to be met by all users of the Airport as may be necessary for the safe and efficient operation of the Airport; and Provided Further, That...[it] may probibit or limit any given type, kind or class of aeronautical use of the Airport if such action is necessary for the safe operation of the airport or necessary to serve the civil aviation needs of the public."[71]

The Court held that the fee structure was not unduly discriminatory because the efficient utilization of airspace was a valid ground on which to establish preferential landing and take-off assignments. The Court went on to say

> If it be true that all persons have equal rights of access to the navigable air space, then it is not undifferentiated aircraft by count that must be treated equally in landing approach and take-off. One aircraft approach may represent the right of over 150 passengers to have access to the navigable airways and landing areas. The next plane may represent the right of one or two persons to have access to the airways and landing areas. To treat them all alike in allocating scarce landing and take-off time and space <u>is to ignore and not to recognize the basic right of equal access</u> to airways and landing areas. (Emphasis added.) [72]

The Court then dismissed the third contention as well, holding that air taxis are closer to mass transportation and covered by the over-all public interest principle.

> Given the unquestioned fact of airport congestion at the three airports, the revised fee schedule draws a perfectly rational line in separating mass transportation and its auxiliaries from other aviation. The efficient utilization of air space in the interest of the greatest number of users of the airspace plainly justifies the first distinction between large and small aircraft.... The narrowly restricted exemption of air taxis that in effect operate as connecting carriers and do not use interfering runways is justified by the evident immediateness of connection with the dominant, mass transportation concern of the air terminals.[73]

Summary

The use of a surcharge and quota system was a very effective way to displace general aviation traffic from the major New York airports, making more operations available for air carriers and reducing delay significantly. It is estimated that the surcharge displaced an average of 4000 GA flights per month* and the quota system an additional 5,500 [74] (with reference to the peak month of July, 1968, when there were 91,000 total operations at the three airports: 67,000 airline and 24,000 general aviation[75]). The number of aircaft delayed by 30 minutes or more during June through September, 1969, fell to 8.3% (29,842) of total operations (359,192) as compared to 12.1% (41,760) of total operations (385,066) for the same period in 1968.[76]

Although the legal issues as to whether the FAA can impose quotas and airport operators can impose surcharges have not been settled by the Supreme Court, the reasoning of the lower courts seems sound, which is probably why they were not appealed. From that same reasoning, an airport operator could not impose a quota system under its own authority, but must rely on the FAA. Whether the FAA could legally charge a landing surcharge for its services

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* Mr. Joseph Windisch of the Port Authority, informally estimates that the fee would have to be $50.00 to be as effective today.

is beyond the scope of this study. However, judging from the reactions to the 1973 DOT Cost Allocation Study which advocated that FAA operations should be funded by user fees, any attempt by the FAA to impose landing surcharges would cause a great political controversy at this time.

References for Section VI

1. British Airports Authority. Annual Report and Accounts, 1974/1975(1975).

2. Ibid.

3. Ibid.

4. Ibid.

5. Civil Aviation Authority. Annual Report and Accounts 1974-1975(1975).

6. Ibid.

7. Supra, note 1.

8. Most of the information in this section is based on data provided by Mr. Chris Burnley, Director of Finance for BAA, and Mr. C. John Phillips, BAA's Chief Economist, Finance.

9. Computed from BAA Increases Landing Charges, British Airports Authority News Release (August 20, 1975).

10. Miller, Dennis. "Airport Prices-Theory and Practice". Airports International (July, 1973).

11. Supra, note 8.

12. Supra, note 9.

13. Supra, note 9.

14. Supra, note 8.

15. Data supplied by the British Airports Authority.

16. Ibid.

17. Supra, note 8.

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25. Ibid.

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27. Ibid.

28. Ibid.

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30. The Port Authority of New York and New Jersey. 1974 Annual Report (1975).

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33. Aircraft Owners and Pilots Association et al. v. Port Authority of New York, et al. 305 F.Supp.93 (DCNY, 1969); 11 Avi.17,190, p. 17,192.

34. Supra, note 32.

35. Ibid.

36. Supra, note 31.

37. Aviation Department. Monthly Summary Report of Airport Activities, Port of New York Authority Memoranda (January, 1967-December, 1969).

38. Ibid.

39. Supra, note 32.

40. Ibid.

41. Ibid.

42. Ibid.

43. 33 Federal Register (F.R.) 12,580; 33 F.R. 17,896; 14 Code of Federal Regulations (C.F.R.) §§ 93.121 to 93.133.

44. 33 F.R. 17,897.

45. Supra, note 33, p.17,193.

46. 33 F.R. 17,897.

47. Supra, note 33, p.17,194.

48. 14 C.F.R. § 93.123a.

49. 14 C.F.R. § 93.123a.

50. 14 C.F.R. § 93.123b.

51. 14 C.F.R. § 93.129.

52. 34 F.R. 2,603.

53. Supra, note 31.

54. Ibid.

55. Ibid.

56. Ibid.

57. 38 F.R. 29,463, 14 C.F.R. § 93.133.

58. Supra, note 37 (January, 1967 - December, 1970).

59. Supra, note 31.

60. Ibid.

61. 33 F.R. 17,897.

62. Unreported - Civil Action No. 927-69, rendered by Judge Gesell in the District of Columbia, May 14, 1969 and cited in AOPA v. PONYA, supra, note 53.

63. 49 United States Code (U.S.C.) § 1304.

64. Supra, note 62.

65. Ibid.

66. Supra, note 33.

67. American Airlines, Inc. v. Town of Hampstead, 272 F. Supp. 226 (EDNY, 1967) aff'd., 398 F.2d 369(2d Cir., 1968), cert. den., 393 U.S. 1017 (1969). Allegheny Airlines v. Village of Cedarhurst, 238 F.2d 812 (2d Cir., 1956).

68. Supra, note 33, p.17,198.

69. 49 U.S.C. § 1349(a).

70. 49 U.S.C. § 1110.

71. Supra, note 33, p. 17,195.

72. Ibid., p. 17,199.

73. Ibid.

74. Supra, note 31.

75. Supra, note 37 (July, 1968).

76. Supra, note 31.

VII. SUMMARY AND CONCLUSIONS

The main findings of this report can be summarized as follows:

First, the weight-based landing fees used by the overwhelming majority of United States and world airports encourage additional users by discriminatory charges based on willingness or ability to pay: lighter aircraft with fewer passengers — flights which, on the average, contribute less "transportation value" per operation — are charged lower prices than heavier, higher-capactiy aircraft. This pricing policy is appropriate at underutilized, uncongested facilities where the airport operator wants to attract as many users as possible in order to maximize revenues and recover the highest possible proportion of the initial and marginal facility costs. However, when an airport reaches full capacity, this policy worsens the congestion because a prospective user need only consider his own costs and delay which are but a small fraction of the total marginal costs that his aircraft movement causes to all other users especially if that user is a light aircraft operator.

Second, administrative measures, such as hourly quotas or total bans on specific categories of aviation, can effectively deal with congestion problems in the short run. If, however, these administrative policies are not coupled with economic considerations, they may lead to poor results in the long run. By indefinitely maintaining the status quo (in terms of the character and identity of the airport users and of the capacity of the airport), the type and quality of the transportation service may seriously deviate from what would maximize social benefits. The economic signals for growth and/or change are suppressed.

Third, the "value of transportation" at a congested airport is maximized if and only if each airport user is charged full marginal delay costs. Each additional flight must pay for all the additional costs it imposes on other

passengers and aircraft operators. If ticket prices are flexible, it is immaterial whether these marginal delay costs are charged to the airline for each flight or whether they are directly charged to the passengers on the flights because the airline will ultimately pass the charge on to the passengers. However, where ticket prices are fixed by regulation, the congestion tolls (equal to marginal delay costs) should be charged to the airlines for each flight rather than be assessed to the passengers directly. Otherwise, the carriers will continue to compete through service by offering excessive frequency and will change the size of the aircraft used rather than eliminate flights.

Fourth, a time-varying structure of airport usage fees based on the principle of marginal cost pricing is theoretically both necessary and sufficient to guarantee the socially optimal utilization of airport capacity. Unfortunately, serious problems arise in practice both in the numerical determination of what these pricing schedules should be and in the implementation of a pricing policy based solely on optimizing total social value without regard for revenue requirements.

The primary difficulties in determining price structures are : the near impossibility of estimating the elasticities and cross-elasticities of airport demand with respect to airport usage charges (especially for airlines with a tightly interdependent flight schedule) and the lack of sufficiently powerful mathematical techniques for dealing with the "dynamics" of shifting demand as runway prices change.

At the implementation level, an airport's financial objectives (such as recovering investments or meeting a specified return on investment) are unrelated to the objective of maximizing the value of the transportation provided to society. If these objectives are incompatible, the implementation of a pure, marginal-cost-based pricing structure may be blocked.

Fifth, perhaps the most important obstacle to implementation of marginal cost pricing at major airports is the fact that, in its pure form, such a pricing system does not consider a user's willingness or ability to pay: each user is simply charged for all the delay costs that he imposes on others. During peak-traffic periods, the resulting charges may be hard or impossible to bear for certain kinds of aviation. Specifically, high landing charges, when considered as a percentage of a flight's value to the aircraft operator, will have the greatest impact on general aviation, then "third-level" commuter flights, then short-haul regional carrier flights and finally short-haul trunk carrier flights. Most of the reduction in peak-hour operations as a result of marginal cost pricing is likely to come from these categories.

Although this is entirely consistent with the desired effects of the pricing policy — those who use the airport will be the ones who derive the highest value from such use — airport and civil aviation authorities everywhere will probably be reluctant to adopt in one sudden step a practice which is so drastically different from the current system. The reasons for this reluctance may be, on the one hand, "political" (i.e. apprehension about the various forms of opposition that a policy change of this type will probably generate) and, on the other hand, uncertainty regarding the immediate and long-term effects that a completely new pricing policy will have on airport use.

Based on these findings, the following overall conclusions regarding the potential role of alternatives to capital investment in more efficiently allocating and utilizing existing airport capacity can be drawn:

First, the present weight-based methods for computing runway fees are as good as any for recovering costs at uncongested airports seeking "self-support".*

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* "Self-support" is used here in a qualified manner to indicate recovery of direct construction, maintenance and operation costs for airport facilities and ignores the large, indirect subsidies that airports receive from taxpayers at large.

Aircraft weight is an adequate proxy for an operator's willingness and ability to pay and approximates the marginal facility costs imposed by different types of aircraft use. As soon as significant congestion problems begin appearing at an airport, however, the weight-based runway fees become counter-productive.

In this case administrative measures (probably in the form of hourly quotas) for limiting airport demand during periods of congestion can be applied. These measures, however, should be viewed only as effective "stop-gap" solutions unless they are coupled with some type of pricing mechanism for determining the value of the time-slots to potential users. Reliance on purely administrative measures for a long time leads to distortions both in the quality and type of the transportation provided and in the perceptions of transportation planners regarding the urgency and need for airport capacity expansion.

Peak-hour surcharges based on the increased marginal delay costs during peak traffic hours are a better method for limiting use than a quota system, but the problems of determining what the peak-hour surcharges should be and what the impact of a peak-hour surcharge (in its pure form which does not consider the user's ability to pay) may be on the air transportation system must be solved. The question is not whether they should be adopted but how.

The best solution for congested airports may be a hybrid system that combines a quota to meet immediate needs with the gradual introduction of time-dependent pricing as the quota is phased out. Specifically, a congested airport would impose a quota limiting the operations permitted to a number that could be handled without significant congestion or delay. At the same time, a small peak-hour surcharge would be imposed during peak periods. A few users might decide they no longer want to operate during the peak because of the surcharge, but most would be unaffected. The available time-slots would be allocated among these remaining candidates. In this first stage, the

airport uses the surcharge to discourage some users and administrative fiat to select the number of peak-hour operations compatible with reasonably smooth operation of the facility. If the number of candidates willing to pay the initial small surcharge exceeds the quota for smooth operations, it is a signal to the airport that the surcharge is too low.

In the second stage (perhaps after a year or more has elapsed) the peak-hour surcharge would be increased. Fewer candidates will bid for the available slots and the quota system will thus play a less vital role in determining who will use the airport. After a few upward adjustments, the amount of the surcharge should equal the marginal delay costs imposed on other users by an additional user during the peak traffic periods. At that point, a pricing mechanism is fully effective and administrative measures can be fully phased out. <u>Any user, irrespective of identity, who is willing to pay the runway fees at this point should be given access to the airport</u> because the value of access to that user is at least as high as the delay costs he imposes on other users.

If, after marginal cost pricing is fully in effect, the total amount of money collected from peak-hour surcharges is large as compared to the cost of expansion, the value of airport expansion is high and capital investment should be considered.

The main advantages of the scheme just outlined are that it allows for a trial-and-error, yet orderly, determination of an appropriate price structure for use of the airport; that it provides for a long transition period during which both the airport administrators and the airport users have an oppportunity to fully understand the new system and to weigh its consequences for themselves;* and that it permits the users to consider carefully the use of alternative air-

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*It is even possible, in order to smooth the transition, to initially vary the peak-hour surcharges by type of user. In the first stage, for example, a smaller peak-hour surcharge could apply, say, to short-haul than to long-haul flights (to take into account ability-to-pay).

ports and the impact of changes in the timing of flights and the type of aircraft used. Thus, the scheme confronts in a practical way the two main difficulties of implementing pricing mechanisms.

This approach is very close to that actually used by the British Airports Authority. A small peak hour charge was introduced in addition to the existing quota system. It has been slowly increased and made more elaborate as experience has been gained.

In New York the experience was similar except the surcharge was imposed before the quota. Once both were in effect, the desired goal of limiting general aviation at the three major airports was achieved and no further changes in the fee system were needed. In fact, the quotas were removed when experience indicated they were no longer needed.

However, there are still unanswered questions. Will the BAA system have substantial impact on demand as the fee levels become significant over the next few years? Could the New York experience be extended to other classes of traffic? Also, the phase-in approach does not address the problem of how to cover revenue requirements if the peak pricing policy does not generate sufficient funds (which indicates that the facilities are overdeveloped).

With these limitations in mind, the following recommendations can be made:

First, because time-varying runway fees based on delay costs are theoretically the most economically efficient way to allocate existing capacity at congested airports, they should be given the full attention of the Federal Aviation Administration and the airport operators of the United States. The potential savings from postponing or eliminating capital investment and from increasing the efficiency of the air transportation system are enormous.

Second, the FAA and airport operators should closely monitor the BAA experience at Heathrow Airport and consider a similar experiment at a major airport in the United States. The rationale of the BAA's policy and its

intended goals should be fully understood and explored.

Third, further study of approaches that contribute to efficient utilization of existing airport capacity should be encouraged and supported. In particular, the analysis of the problem through the use of recently developed quantitative techniques appears to be a promising area for work with potentially large payoffs.

Fourth, the institutional issues facing the United States before a peak-hour surcharge system could be widely adopted must be explored. These center around whether the charges should be imposed and controlled by the FAA or the local operator and whether the large charges that will be needed to shift demand are politically acceptable. This policy would represent a radical departure from our traditional concepts of free airspace and generally free access to aviation facilities and services. In the long run, these institutional issues may be more important than the economic ones.